ST-5000

DEMODULATOR

INSTRUCTION MANUAL

HAL COMMUNICATIONS CORP.
BOX 365
URBANA, ILLINOIS 61801

QUALITY COMMUNICATIONS EQUIPMENT

HAL ST-5000 FSK DEMODULATOR / KEYER

TECHNICAL MANUAL

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HAL ST-5000 DEMODULATOR

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I. INTRODUCTION

The Hal Communications Model ST-5000 is a high performance FSK demodulator and tone keyer designed for use with radio teleprinter systems. The ST-5000 incorporates the features and performance characteristics of previous HAL demodulators as well as offering some features previously not available.

The ST-5000 is an audio tone type of demodulator and keyer. Audio tones from the receiver, representing the "mark" and "space" teleprinter code states, are converted into keying pulses by the demodulator section. Active discriminator filters are used in the ST-5000 so that a wide range of input frequencies can be accomodated. Two standard audio tone sets are normally stocked by the factory. The standard tone sets are based on a mark frequency of 1275 Hz ("low-tone" set) or a mark frequency of 2125 Hz ("high-tone" set) for frequency shifts of 170 Hz and 850 Hz. The tone keyer section of the ST-5000 generates the same set of tones for transmitting in addition to a narrow-shift tone for Morse code identification.

The demodulator uses a wide bandwidth limiter and active detector circuit to give outstanding performance for a wide range of input signal amplitudes. A three pole active lowpass filter follows the detector stages to reduce the post-detection noise bandwidth.

The ST-5000 autostart circuit senses the presence (or absence) of a valid teleprinter signal. If the input signal is not recognized as a teleprinter signal, the printer is held in the "mark-hold" condition. If more than twenty seconds pass without recognition of a valid signal, the power to the printer motor is removed.

As mentioned earlier, the tone keyer generates the same tone set as is used in the demodulator section to assure true "transceive" conditions. The tone keyer will also generate an additional narrow-shift tone that can be connected to an external keyer circuit for Morse code identification. All tones of the tone keyer are derived from a type 55 IC oscillator. The output signal is a low distortion sinewave generated in a digital-to- analog converter and then filtered in an active low-pass filter. A wide range of output amplitude (into 500 ohms) is available from the ST-5000, adjustable with an internal control. The shift of the tone keyer is controlled by the front panel SHIFT switches. The SENSE switch (NORM - REV) controls only the demodulator, not the tone keyer.

The audio input to the demodulator and the audio output from the tone keyer are both 500 ohms unbalanced with respect to ground. The oscilloscope signals for a crossed-ellipse oscilloscope display are connected to a rear panel connection. The ST-5000 is furnished with a front panel tuning meter.

Internal, electronically regulated $\pm$ 12 volt power supplies provide operating voltages for the demodulator, control, and tone keyer sections of the ST-5000; a 175 volt, 60 ma. loop power supply is also included. The main power transformer of the ST-5000 can be connected for operation with either 105 to 125 VAC or 210 to 250 VAC, 50 or 60 Hz power sources. The power line fuse is accessable from the rear panel of the unit. The ST-5000 requires approximately 20 watts of AC power and is housed in an attractive

blue and beige cabinet that matches the HAL Communications DS-3000 and DS-4000 KSR and RO Video Display Terminals.

A complete set of connectors are furnished with the ST-5000 to simplify the initial installation. If you are anxious to try your ST-5000, it is suggested that you skip to sections 3.1 and 3.2 of the installation chapter and then read sections 4.1 and 4.2 of the operation chapter before turning the equipment on. The balance of this manual should then be studied before attempting any "custom" connections.

2. SPECIFICATIONS

Input Section:

Data:	Serial, tone-encoded data, up to 110 baud
Input Amplitude:	-60 to +20 dBm (approx. 1mV to 10V rms)
Input Impedance:	500 ohms, unbalanced
Input Frequencies:	
"Low-tones"	Mark = 1275 Hz Space = 1445 Hz (170 Hz shift = "NARROW") Space = 2125 Hz (850 Hz shift = "WIDE")
"High-tones"	Mark = 2125 Hz Space = 2295 Hz (170 Hz shift = "NARROW") Space = 2975 Hz (850 Hz shift = "WIDE")

Discriminator Filter Bandwidth: 190 Hz

Tone Keyer Section:

Data:	Serial data from loop circuit, up to 110 baud
Output Amplitude:	Variable from -40 to 0 dBm (approx. 10mV to 1.00V)
Output Impedance:	500 ohms, unbalanced
Output Frequencies:	Same as those given above for input section plus:
CW-ID:	1175 Hz ("Low-tones"), key down 2025 Hz ("High-tones"), key down

Autostart Section:

Print-control response:	2 to 4 seconds
Motor turn-off time:	20 to 40 seconds
Motor control:	Relay switched power line voltage to accessory socket; up to 8.0 amperes (1/4 HP).

Tuning Indicator: 0-1 ma front panel meter; rear panel connections to an external oscilloscope are provided.

Mechanical Specifications:

Size:	12 1/8" W x 7 7/8" D x 2 13/16" H 30.8 x 20.0 x 7.1 cm
Weight:	5.75 lbs (2.6 kg), NET 7.00 lbs (3.2 kg), Shipping
Finish:	Two-tone, blue top over beige bottom, matches ST-6000, DS-3000 KSR and other current HAL Products.
Power Requirements:	105-125 VAC (210-250 VAC optional), 50-60 Hz, 15 Watts

3. INSTALLATION

3.1 Initial Inspection

Upon receipt of the ST-5000, unpack and inspect it carefully for shipping damage. If evidence of shipping damage is found, contact the carrier immediately. Before discarding the packing material, check that all parts and accessories are accounted for. If any are missing, please notify the factory or distributor in writing so that replacements can be supplied. The following parts and accessories are furnished with the ST-5000.

Accessory parts:

1	-	Non-captive AC power cord
1	-	6 ft. Audio cable, phono connectors each end
4	-	3 pin female connector shells (03-09-2031)
2	-	6 pin female connector shells (03-09-2061)
24	-	male cable pins (02-09-2143)
2	-	0.5 ampere, slow-blow fuses
6 ft	-	2-conductor shielded cable

CAUTION! A SERIOUS SHOCK HAZARD MAY EXIST WHEN CONNECTING THE ST-5000 TO OTHER EQUIPMENT. BEFORE MAKING ANY CONNECTIONS, BE SURE TO DISCONNECT THE ST-5000 AND OTHER EQUIPMENT FROM THE AC POWER LINE.

3.2 Audio Connections

Audio tones from the receiver as well as ST-5000 tones to the transmitter are both connected via the three pin AUDIO jack on the rear panel. It is highly recommended that the ST-5000 input be connected to a 500 ohm audio output from the receiver. Although the demodulator will work when driven from a lower impedance source (4-8 ohms, for instance), the voltage level from most receivers is insufficient to take full advantage of the wide sy-namic range of the ST-5000 input circuitry. Use of a 4 ohm output instead of a 500 ohm output causes a loss of 22 dB in the audio signal strength, which may impair the weak signal capabilities of the RTTY receiving system. If the receiver does not have a 500 ohm output, a 4 to 500 ohm transformer is highly recommended.

The tone keyer output is also connected to the AUDIO connector. This output has a nominal source impedance of 600 ohms, but may be used to drive high impedance audio circuits as well. The output level of the tones is adjustable over the range of 0 to -40 dBm (1.0 V to 10 mV rms) as is described later in section 4.7.

Connections between the receiver and transmitter and ST-5000 can be made using the 6 ft. phono cable supplied. Cut the cable in half; connect one section between pins 1 and 2 (shield) for the receiver audio connection. Connect the other half between pins 3 and 2 (shield) for the transmitter audio input connection. Preparation of the plastic connector and pins is illustrated in Figure 3.1; connections to the AUDIO connector are shown in Figure 3.2.

3.3 Loop Connections

The station RTTY equipment can be connected to the ST-5000 internal loop circuit through pins 1 (+) and 4 (-) of the I/O - CONTROL rear panel connector. The internal loop supply generates a 60 ma dc current flow for mark condition from a 175 volt dc power supply. If a polarity sensitive device such as a solid state keyboard or display generator is connected in the loop circuit, be sure to observe proper polarity connections. Preparation of the plastic connector and pins is shown in Figure 3.1; some common loop connections are shown in Figure 3.3.

C A U T I O N

THE 175 VOLT LOOP POWER SUPPLY CAN CAUSE A LETHAL ELECTRICAL SHOCK IF CONTACTED. BE EXTREMELY CAREFUL WHEN CONNECTING EQUIPMENT IN THE LOOP CIRCUIT TO BE SURE THAT POWER TO THE ST-5000 IS DISCONNECTED. BE SURE TO GROUND THE CABINETRY OF ALL EQUIPMENT CONNECTED IN THE LOOP CIRCUIT AND PROVIDE PROTECTIVE INSULATION FOR ALL LOOP CONNECTION POINTS.

3.4 FSK Connections

A low-voltage data output is also available on the I/O - CONTROL connector at pin 3, labeled "FSK." This signal is derived from the loop circuit and will provide approximately -15 volts on mark condition and +15 volts on space condition. This signal is compatible with a RS-232C data standard and can be used to directly drive solid state display systems such as the HAL RVD-1005 or the DS-3000 KSR units. This signal can also be used to drive saturated diode FSK keying circuits. Preparation of the connector is shown in Figure 3.1 and typical FSK connections are shown in Figure 3.4.

3.5 STANDBY Connections

As explained in section 4.5 , the ST-5000 can be locked into a mark-hold condition where the loop (and FSK) data outputs do NOT respond to an audio input signal. This feature allows "local loop" operations such as preparing tape and transmitting while still using the loop supply of the ST-5000. This mode can be activated by either using the LOCAL position of the front panel LINE switch or by grounding the STANDBY pin (no. 2) of the I/O - CONTROL rear panel connector. The REMOTE feature is generally connected to a pole of the transmit-receive switch or relay so that the demodulator is disabled while transmitting. As before, refer to Figure 3.1 when preparing the connector pins.

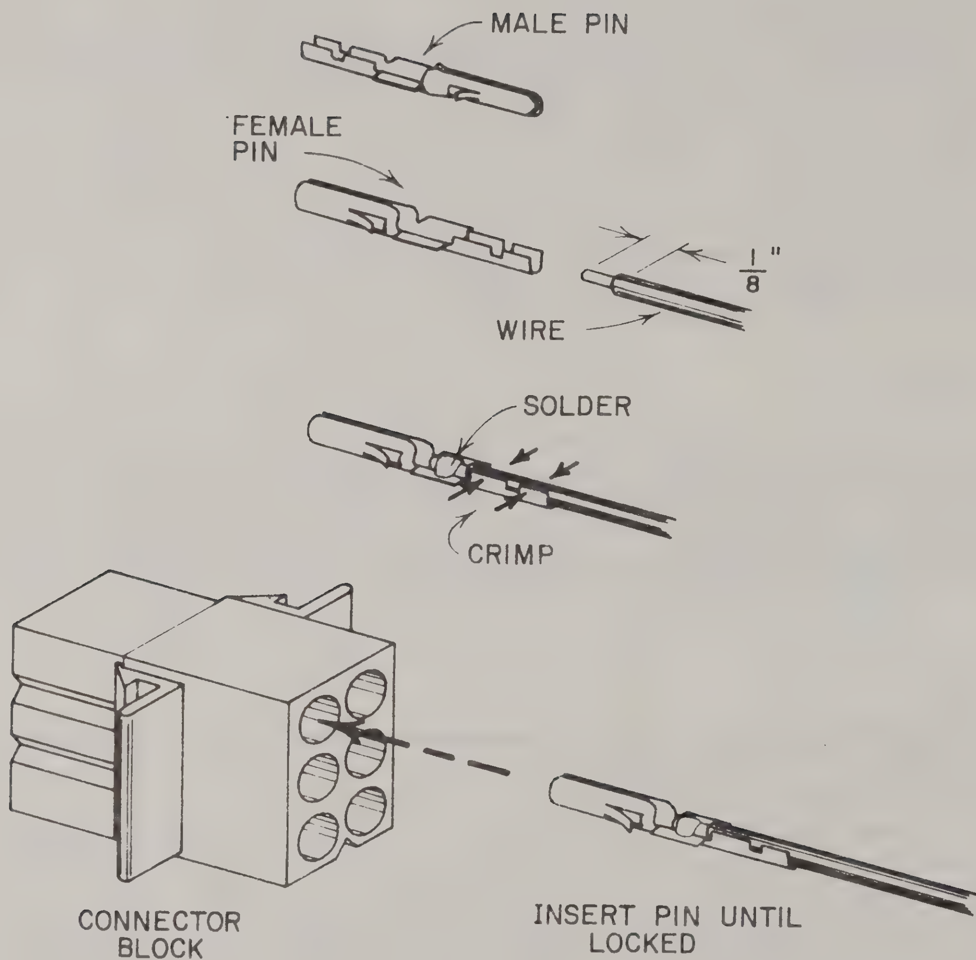
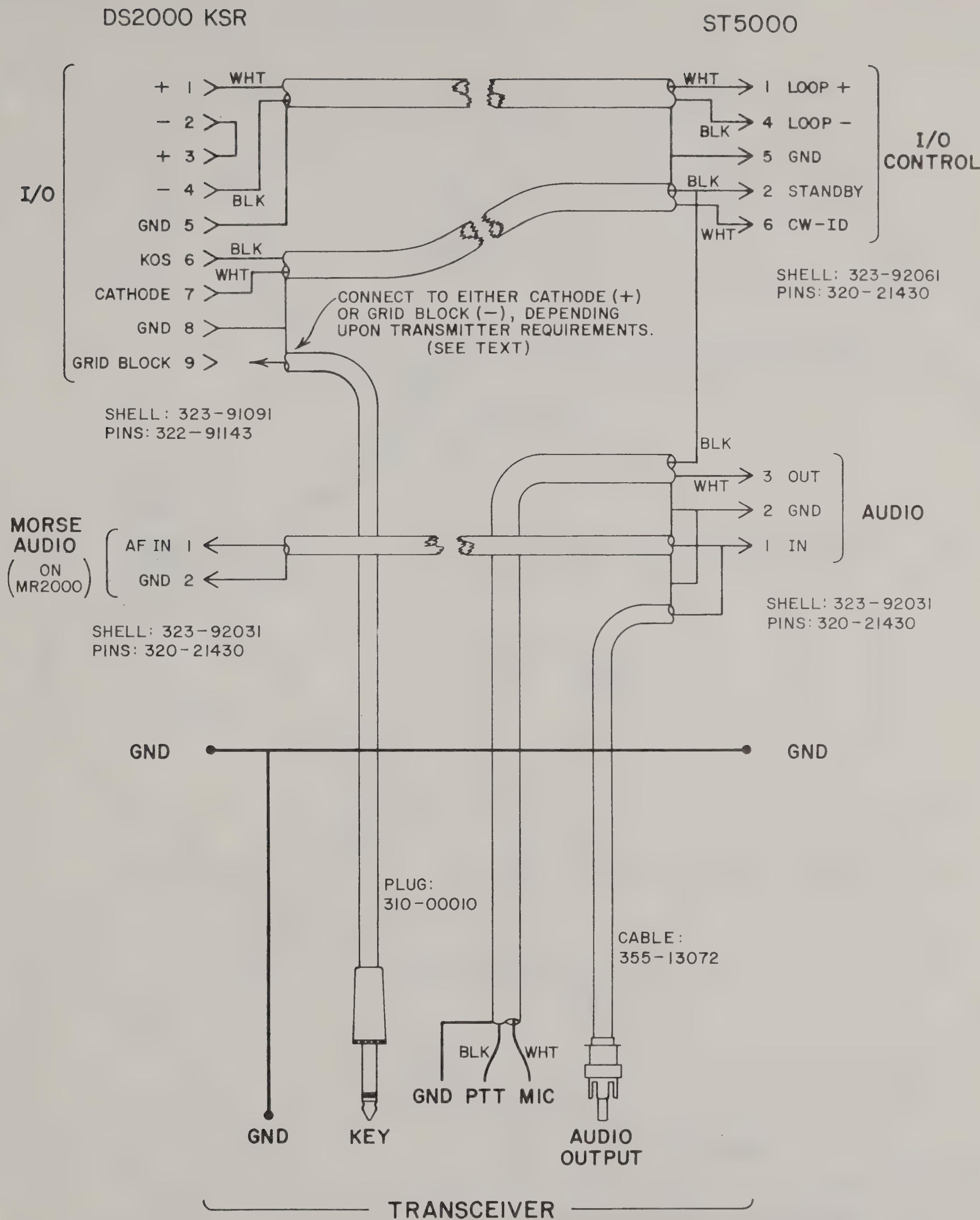
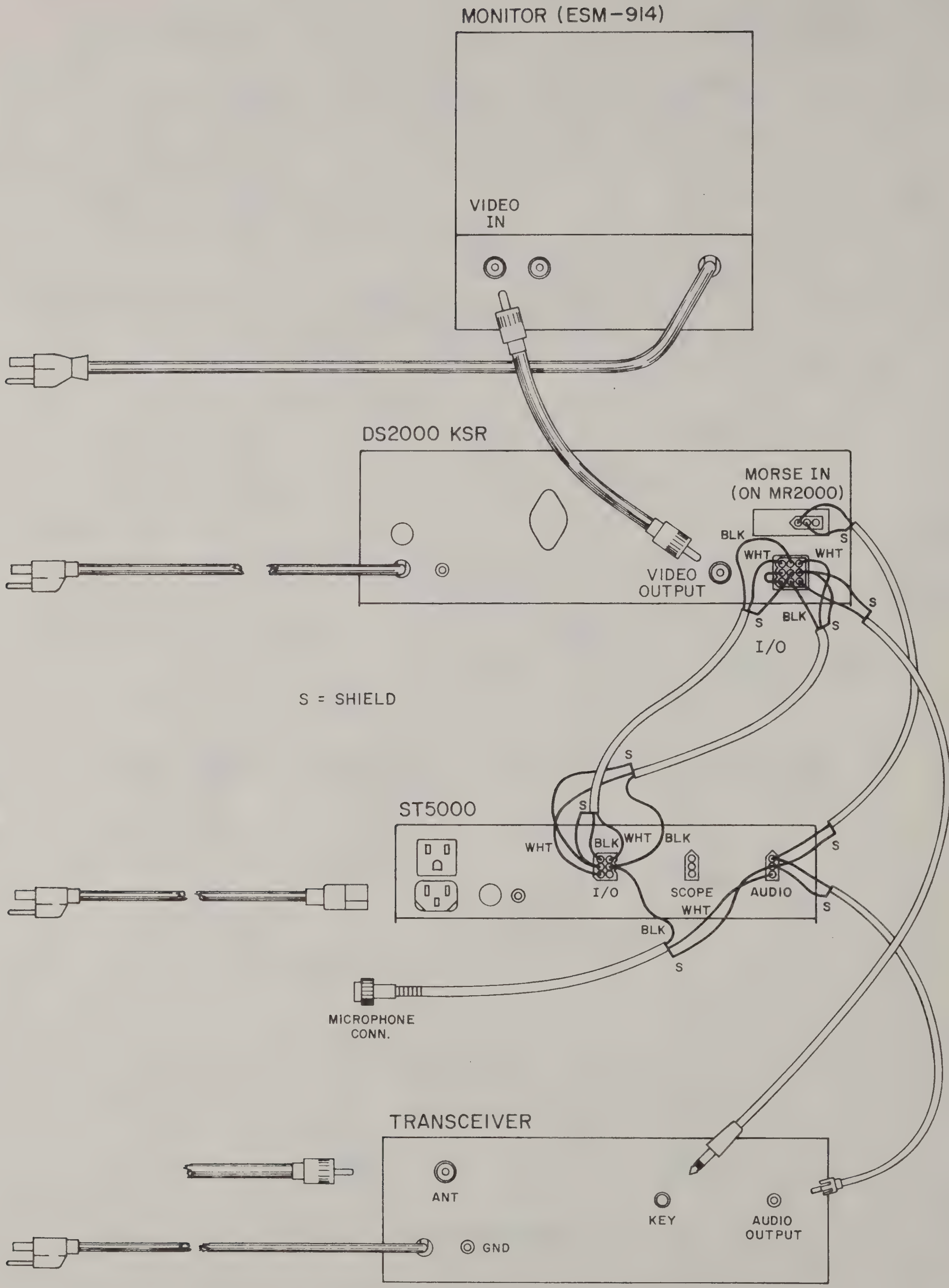


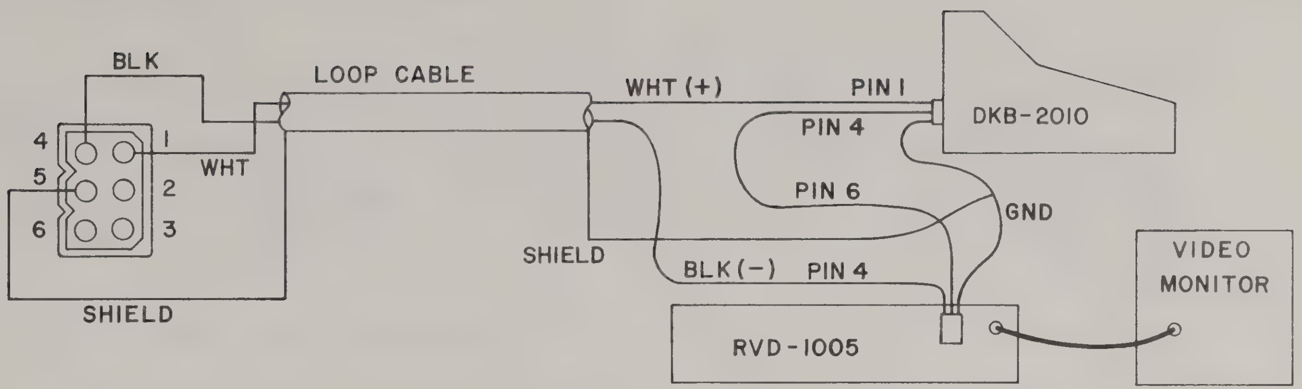
Figure 3.1 Connector Preparation



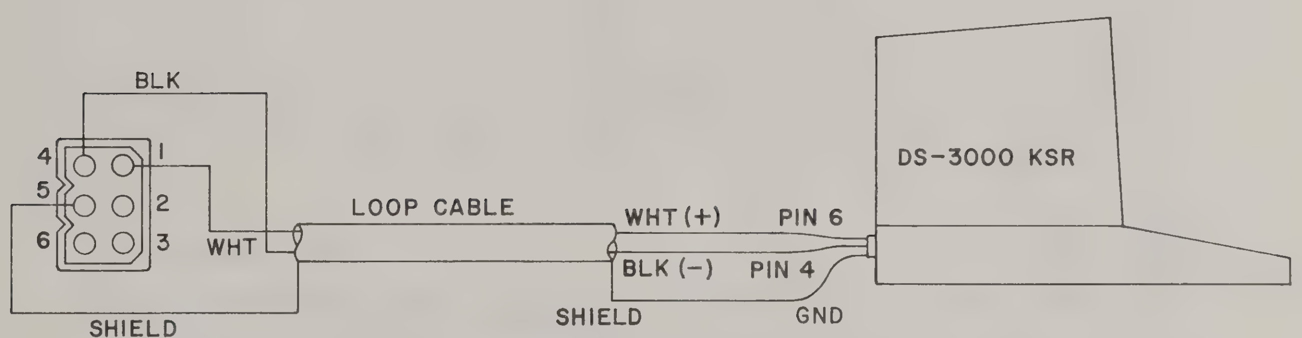
DS2000 and ST5000 System Connection Schematic



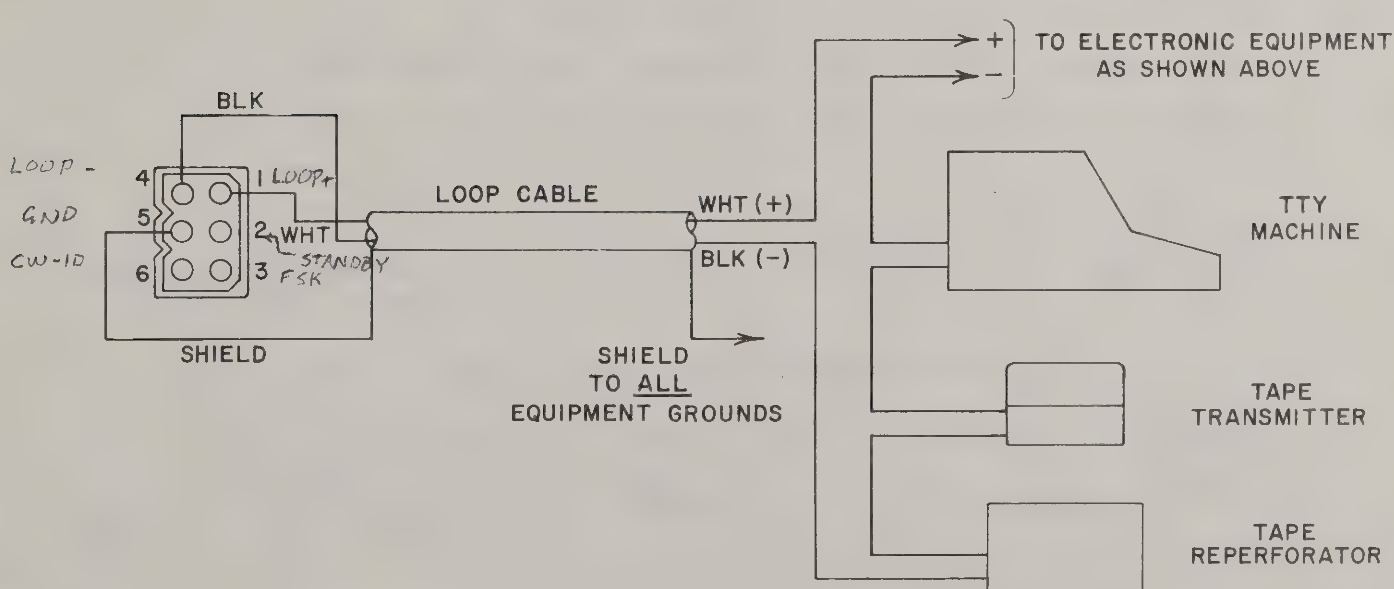
DS2000 and ST5000 System Connection Pictorial



LOOP CONNECTION OF DKB-2010 AND RVD-1005

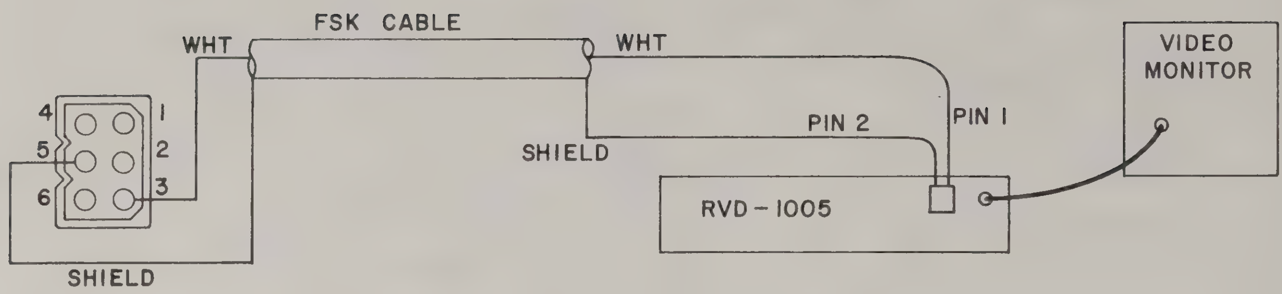


LOOP CONNECTION OF DS-3000 KSR

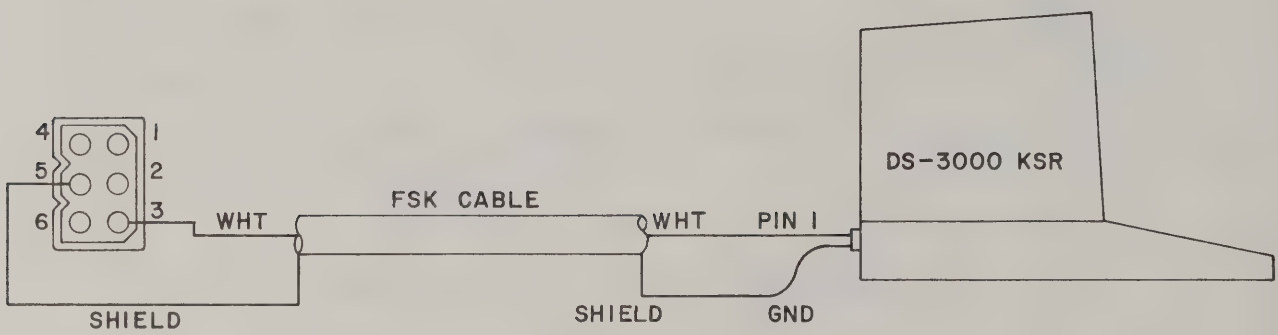


LOOP CONNECTION OF ELECTRONIC AND MECHANICAL EQUIPMENT

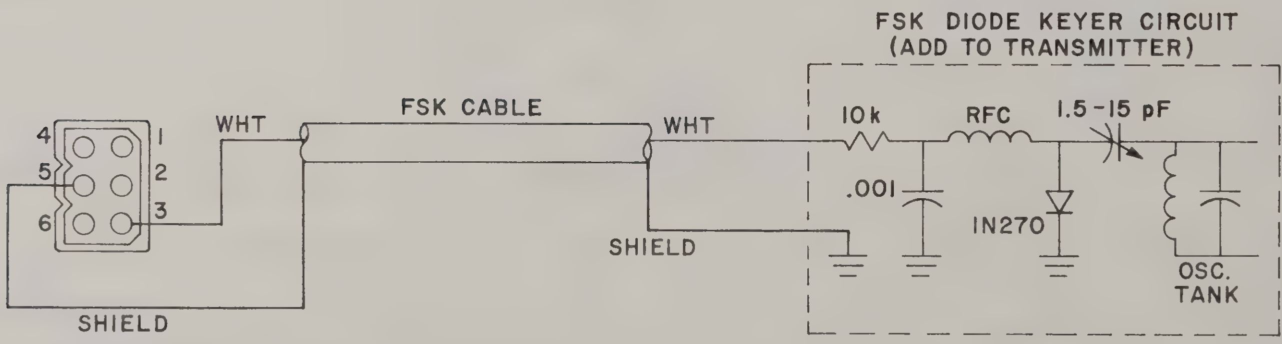
Figure 3.2 Loop Connections to the ST-5000



USE OF FSK OUTPUT TO DRIVE THE RVD-1005



USE OF FSK OUTPUT TO DRIVE THE DS-3000 KSR



USE OF FSK OUTPUT TO DRIVE DIODE FSK CIRCUIT

Figure 3.3 FSK Connections to the ST-5000

3.6 CW ID Key Cable Connection

Pin 6 of the I/0 - CONTROL connector is labeled "CW-ID." Connect the station Morse code hand key or electronic keyer between this pin and ground (pin 5) to provide narrow-shift CW identification of the transmitted signal. When an electronic keyer is used, the output circuit for cathode keying should be used, instead of the grid-block keying circuit. In no case should the keyer reflect any negative voltage or positive voltages greater than +12 to the ST-5000.

3.7 AC Power Cord Connection

The ST-5000 can be internally connected to operate from power sources in two voltage ranges: 105 to 125 VAC or 210 to 250 VAC, 50 or 60 Hz. The rear panel power cord connector is of the "universal" USA/European type and mating power cords can be obtained for most common wall connectors. The ST-5000 is normally factory wired for operation from 105 to 125 VAC, 50 to 60 Hz power lines. Upon request at the time of the order, the ST-5000 can also be supplied for 210 to 250 VAC, 50 to 60 Hz operation. When the 210 to 250 VAC connection is supplied, it is indicated by a small tag on the rear panel of the ST-5000. If this tag is NOT on the rear panel, do NOT connect the ST-5000 to a 240 volt line without first checking the internal wiring of the power transformer. Particular attention should be given to the precautionary notes of section 3.8 when connecting to the MOTOR receptacle.

3.8 Motor Power Connection

The power for the teleprinter motor can be supplied by the MOTOR connector of the ST-5000. The power to this connector is controlled by the autostart relay. The TOTAL current supplied by this receptacle should not exceed 10.0 amperes. The following precautions should be observed when using the MOTOR receptacle:

1. The power to the MOTOR receptacle is NOT fused in the ST-5000. The user should be sure that any device attached to this connector has its own fuse protection.
2. The AC voltage furnished on the MOTOR receptacle is the SAME as the AC power line voltage supplied to the ST-5000; if the ST-5000 is operated from a nominal 240 VAC power line, the MOTOR receptacle also furnishes 240 VAC.

The proper power transformer primary connections are:

105 to 125 VAC, 50/60 Hz: jumper terminal 1 to 3 and 2 to 4, connect power line to terminals 1 and 4.
210 to 250 VAC, 50/60 Hz: jumper terminal 3 to 2, connect power line to terminals 1 and 4.

3.9 Ground Connection

The ST-5000 cabinet should ALWAYS be connected to an adequate ground system. A three-prong grounding type AC power plug is furnished for connection to a grounded-outlet power system (105-125VAC connection). If the wiring of the building is correct, use of the grounding AC plug should provide an adequate SAFETY ground return for the instrument. However, it is a good idea to first check the outlet wiring with a multimeter before plugging in the unit. If a three-prong AC outlet is not available, use a three to two-prong adapter at the wall socket and connect a separate ground lead between the adapter ground lead or ST-5000 cabinet and a good ground. When using 210 to 250 VAC power mains, be sure to connect the cabinet to a good safety ground. OPERATION OF THIS EQUIPMENT WITHOUT AN ADEQUATE SAFETY GROUND INVALIDATES THE WARRANTY.

When the ST-5000 is used in a radio communications system that includes a high-powered transmitter, a short length of low-inductance wire (¼" wide shield braid is recommended) should be used to interconnect all equipment cabinets, including the ST-5000 and all teleprinters, etc. Lack of a good RF ground connection may cause false triggering of the logic in the control sections or other improper operations. Open-wire antenna feedline systems with high standing-wave-ratios can be particularly troublesome to solid state equipment. In such cases, changing the antenna, matching system, and/or feedline to a matched coaxial line system will usually clear-up RF interference. When good RF grounds and low SWR feed-lines are used, the ST-5000 will work with even very high powered transmitter systems.

Obviously, a great many other I/O and control connections can be made. The user should thoroughly study section 5 and understand how the various sections of the ST-5000 operate and interact before these connections are made.

3.10 External Oscilloscope Connections

The MARK and SPACE AC signals from the discriminator filters are available on the rear panel SCOPE connector. The signals are approximately 2.0 volts peak-to-peak amplitude into a recommended 100 k ohm minimum load impedance. The MARK signal is available on pin 3, the SPACE on pin 1, and signal ground on pin 2.

4. Operation

The ST-5000 contains many advanced features designed to assure convenient operation. The operating instructions presented in this section will help you to take full advantage of the demodulator's capabilities. Please read all sections carefully.

4.1 Front Panel Controls and Indicators

The ST-5000 front panel has a total of five push-button switches that allow operator control of the demodulator. Normal operation of the demodulator with ALL automatic features active is obtained by depressing the four right-hand switches and selecting the desired shift with the far-left switch. These functions will be discussed in greater detail later in this section and in section 5. Table 4.1 describes the front panel switches.

Table 4.1 ST-5000 Front Panel Controls

SWITCH	POSITION	FUNCTION
POWER	ON - OFF	Controls AC power to ST-5000
PRINT	LINE	Allows received data to drive printer
	LOCAL	Locks printer in mark for "local-loop" operation
AUTOSTART	ON - OFF	Turns autostart circuit on or off
SENSE	NORM	Normal signal polarity; mark = lower tone
	REV	Reverse signal polarity; mark = higher tone
SHIFT	NARROW	Selects 170 Hz shift
	WIDE	Selects 850 Hz shift

The rear panel connectors have been discussed in detail in section 3 and internal adjustments will be discussed in detail later in this manual.

4.2 Simplified Operation Procedure

The following procedure is suggested for those operators who are anxious to try the ST-5000 without reading the rest of this manual.

1. Prepare audio input and printer cables as described in sections 3.2 & 3.3 and connect the unit to a receiver and printer or display. Do NOT connect a transmitter without reading the rest of section 4 of this manual.

2. AFTER CONNECTIONS ARE MADE, plug-in the ST-5000 and other equipment and turn on the AC power to each.

3. Set the ST-5000 switches as follows:

   POWER - ON

   PRINT - LINE

   AUTOSTART - OFF

   SENSE - NORM

   SHIFT - select desired shift

4. Set the receiver to LSB mode and tune to a FSK RTTY signal. (Approximately 3600 kHz at night and 14,100 kHz during the day are good frequencies to look for 170 Hz shift radio amateur RTTY signals at 60 WPM).

5. Tune the receiver dial until the tuning meter deflects up-scale to approximately 0.6 to 0.7 and has minimum fluxuation as the signal changes from mark-to-space. (If an oscilloscope is connected, tune for perpendicular ellipses on the screen).

6. The printer should now print the received signal. If it doesn't, try reversing the SENSE switch or selecting different speeds on the printer or display.

7. NOW, read the rest of this manual!

4.3 Reception of Radio Teleprinter Signals

Radio teleprinter signals are usually generated in two forms: direct shifting of the transmitter carrier frequency by the mark and space teleprinter data (called "FSK") or by shifting the frequency of audio tones with the data and using the audio tones as modulation in either an AM or FM transmitter (called "AFSK"). FSK transmissions are usually used in the HF frequency range, below 30 MHz and AFSK is the normal technique for VHF transmissions, above 30 MHz. A currently popular method used to transmit FSK signals is to apply the frequency-shifted tones as modulation to a single side-band (SSB) transmitter. Since a properly adjusted SSB transmitter signal is the same as that by direct FSK, a separate RF frequency for mark and space data conditions. Reception of such signals is therefore exactly the same as if direct FSK had been used. Use of this technique will be discussed in greater detail in section 4.8.

4.3.1 Receiver for FSK Reception

The performance of the ST-5000 depends to a great extent upon the characteristics of the receiver used and the care taken in tuning the FSK signal. Obviously, the better suited the receiver, the better the quality of the printed displayed output. Some of the desirable receiver characteristics and features are:

1. The receiver should preferably be of the SSB type with selectable sideband. Standard convention is to use LSB mode for FSK reception.

2. The frequency stability of the receiver should be very good - a small amount of drift when receiving a 170 Hz shift signal can cause poor print from even very strong signals.

3. The tuning ratio of the main tuning knob should be slow to allow precise adjustment of the FSK signal into the receiver.

4. The selectivity of the receiver should be slightly greater than the shift to be received: for 850 Hz shift, a bandwidth of 1200 to 2100 Hz is adequate; for 170 Hz shift, a bandwidth as narrow as 400 Hz can be used. Two limitations should be kept in mind, however; the narrower the bandwidth, the greater the frequency stability requirements on the receiver, and wider bandwidths permit more interference and noise to be processed with the FSK signal.

5. A "slow" agc with fast attack and slow decay is very desirable when receiving FSK signals.

6. As mentioned in section 3.2, a 500 ohm audio output connection or speaker to 500 ohm transformer are highly recommended for connection to the ST-5000 input.

7. An adjustable BFO frequency or adjustable pass-band tuning are very desirable features for reception of FSK signals.

Proper positioning of the receiver's BFO with respect to the IF pass-band and the FSK signal is particularly important. The standard convention when transmitting HF FSK signals is to transmit mark data at the higher RF frequency and space at the lower. The separate mark and space RF frequencies are both received within the receiver IF pass-band and mixed in the product detector with the BFO to produce audio tone beat signals which then drive the ST-5000. Since the audio filters of the ST-5000 follow the demodulator standard of mark being the lower frequency audio tone, it follows that the BFO of the receiver should be HIGHER in frequency than the FSK signal. However, if the signal is inadvertantly tuned-in using USB (upper side-band) mode, the sense can be corrected with the SENSE switch on the ST-5000 front panel.

The receiver BFO frequency positioning also determines the RANGE of audio frequencies that can be detected and used to drive the ST-5000. The normal SSB receiver has generally been designed for optimum performance with voice signals with a typical audio frequency pass-band of 300 to 2400 Hz. However, the so-called "standard" demodulator audio tones have been 2125 Hz for mark with the space tone higher in frequency by the amount of the shift received. For 170 Hz, both the mark (2125 Hz) and space (2295 Hz) tones fall within the 300 Hz to 2400 Hz pass-band, although they are not centered. However, the 850 Hz shift space tone at 2975 Hz is not detected for all but the strongest FSK signals. Obviously, the 850 Hz shift FSK signals are NOT compatible with the usual SSB receiver if the "standard" demodulator tones are used. There are two solutions commonly applied to this problem, both of which are usable with the ST-5000.

One solution is to simply change the receiver BFO frequency so that the audio pass-band of the receiver is changed to, say 1500 Hz to 3600 Hz, which will pass all of the "standard" demodulator tones, centering the pass-band on the 850 Hz shift signal. In this case, the BFO frequency should be changed so that it is FARTHER AWAY FROM THE CENTER OF THE IF PASS-BAND by

approximately 1000 to 1400 Hz. If the receiver BFO is adjustable, this is a simple solution. However, many modern SSB receivers do NOT have adjustable BFO's; rather, the BFO may be crystal controlled. In such cases, the BFO crystal should be changed for one of the correct frequency as determined above. Alternately, the second solution, outlined below, may be used.

The receiver audio pass-band problem can also be solved by changing the tones used by the demodulator for detection of mark and space. This technique, commonly referred to as "low-tones" allows direct use of a voice SSB receiver with no internal modifications to the receiver. The ST-5000 can be furnished with filters designed to accept a mark frequency of 1275 Hz and therefore space frequencies of: 1445 Hz (170 Hz shift) or 2125 Hz (850 Hz shift). In some cases, this can be the best solution. However, as discussed in the next section, it can lead to a basic incompatibility when receiving AFSK VHF signals as well as presenting some transmitter problems. The ST-5000 can also be adjusted for special sets of input tones between 1200 and 3000 Hz on special order.

4.3.2 Receiver for AFSK Reception

The receiver requirements for AFSK reception are not as exacting as those for FSK reception. Since the teleprinter data is an AFSK modulation of the transmitter, receiver stability is not generally critical. However, since the data is in the form of audio frequency modulation, the frequency of the tones is determined at the transmitter and cannot be changed at the receiver by simply adjusting a BFO or similar control. The current VHF-AFSK standards in use by radio amateurs in the United States use the higher-frequency "standard" tones of 2125 Hz for mark and 2295 or 2975 Hz for space, depending upon the shift used. Therefore, a demodulator with "low-tone" input filters will NOT be compatible with reception of current VHF-AFSK signals. As in the case of the FSK receiver, a 500 ohm audio output is certainly desirable, but may not be as important to performancy, particularly if strong-signal VHF-FM signals are used.

4.3.3 Tuning a RTTY Signal

Tuning of the radio receiver for optimum recovery of the teleprinter signal is an operation which may require some practice. Two alternate tuning aids are usable with the ST-5000; the standard tuning meter and a user supplied external tuning oscilloscope. The tuning objective is to adjust the receiver tuning so that the output audio tones match the center frequencies of the ST-5000 filter circuits.

The tuning meter functions in exactly the same manner as that used on the previous HAL models ST-5 and ST-6 demodulators. Portions of the signals from both the mark and space discriminator filters are positive rectified, filtered and summed. The resulting "plus-plus" voltage is used to drive both the tuning meter and the autostart circuit. The amplitude of the "plus-plus" voltage, therefore, depends upon how well the mark or space tones are centered in the discriminator filters. Correct tuning of the receiver is indicated by an up-scale meter deflection that fluxuates very little as the RTTY signal changes between mark and space. The ST-5000 circuits are adjusted so that proper tuning is indicated by a non-varying reading of 0.6 to 0.7 on the meter. Note that the meter may give widely varying readings

when noise, interfering signals, or incorrectly tuned RTTY signals are received. However, it will ONLY give the non-varying, up-scale indication when the RTTY signal is properly tuned.

An external oscilloscope can also be connected to the ST-5000. The oscilloscope presents the standard crossed-ellipse display with the mark signal on the horizontal axis and the space signal on the vertical axis. Because the discriminator filters in the ST-5000 (like those of the ST-5 and ST-6) are relatively broad-band, the mark and space scope displays are NOT lines, but ellipses. The ellipses are fairly narrow when 850 Hz shift is received and wider when 170 Hz is selected. When the RTTY signal is correctly tuned, the ellipses will have maximum length and be essentially perpendicular. The major axis of the ellipse is ALWAYS the parameter to observe and maximize. When the signal is incorrectly tuned, the amplitude of the major axis will be reduced and the two traces may be rotated and/or no longer perpendicular. After using the tuning oscilloscope, the user will discover that, in many cases, the trace positions and amplitudes can be used to determine which direction the receiver dial should be adjusted for correct tuning.

Proper tuning adjustment of the receiver is much more critical when the autostart circuits of the ST-5000 are active than when they are not. This is because the autostart circuitry senses the "plus-plus" voltage which is quite sensitive to the centering of the signals in the discriminator filters. However, if the autostart is not active, the relatively broad bandwidths of the discriminator filters themselves will allow good reception of even poorly tuned RTTY signals. A good operating procedure, then, is to turn the autostart OFF (with the front panel switch) while tuning a signal. When the signal is correctly tuned, the autostart can be activated, if desired. This technique is highly recommended for operators who are unfamiliar with the ST-6 and ST-5000 autostart circuits although, with practice, you may prefer to tune with the autostart circuit on to avoid the garbled print while tuning. Tuning when the autostart is active requires experience and faith in the tuning indicators since there is a delay of 1.5 to 3.5 seconds after correct tuning is achieved before the printer is activated.

The above tuning procedures in general apply only to the reception of FSK RTTY signals. Receiver tuning of AFSK-AM or FM signals will obviously not affect the frequency of the tones. Therefore, tuning of the receiver is not at all critical for AFSK signals. The tuning meter or oscilloscope will indicate the match between the transmitted audio tones and the ST-5000 discriminator filter rather than correct receiver tuning. Obviously, the frequencies of the transmitted tones must match the discriminator filters fairly well for satisfactory autostart operation. Most problems with AFSK autostart systems can be traced to either off-frequency transmitter tones or mis-alignment of the demodulator.

4.4 Use of the SENSE Switch

The SENSE switch allows the ST-5000 to receive signals with either the normal polarity of mark=lower frequency or the reversed sense where mark= higher frequency tone. ALL features of the ST-5000 function equally well for either signal polarity. This reverse position is convenient if the signal has been inadvertently tuned-in using USB rather than LSB receiver

mode. ONLY the discriminator filter frequencies are controlled by this switch; the tone generator sense is NOT switchable.

4.5 Use of the PRINT Switch

There are many occasions in which it is desirable to turn-off the received data to the teleprinter loop circuit and just use the internal loop supply to operate the RTTY machines at the station. Operations such as local testing of equipment or preparation of punched paper tape are typical examples. When the PRINT switch is in LINE position, data from the receiver is allowed to key the loop circuit. When the switch is in LOCAL position, the loop keyer stage is held in mark condition and received data will NOT drive the loop. The demodulator can also be held in LOCAL position by grounding the STANDBY line on pin 2 of the I/O CONTROL connector.

4.6 Use of the Autostart Circuitry

The ST-5000 autostart circuit operates in a manner very similar to that of the ST-6000, ST-5 and earlier TT/L and TT/L-II demodulators. The autostart provides a two-step control of the printer - mark-hold and control of the AC power to the printer motor. The autostart circuit senses the voltage on the "plus-plus" line, which is, as described previously, proportional to the frequency match between the signal tones and the discriminator filters. If both mark and space tones are not sensed in the discriminator, the "plus-plus" voltage remains at a low average value and the autostart circuit will be in the standby condition, giving a continuous mark output. After the autostart has remained in the standby or mark-hold condition for 20 seconds (nominal), the power to the MOTOR AC socket on the rear panel is turned off with an internal relay. If valid mark and space tones are now sensed in the discriminator, the "plus-plus" voltage will increase and activate the autostart after a delay of 3.5 seconds. The AC power to the MOTOR connector is now switched on and the data is allowed to drive the loop. Immediately after the tones turn-off at the end of a transmission, the autostart returns the data to mark hold, completing the cycle.

Because of the turn-on delay inherrent in the autostart, it is recommended that tuning of the RTTY signal be done with the AUTOSTART switch in the OFF position during initial testing of the ST-5000. After the operator has some practice in tuning the receiver, he may then wish to leave the autostart circuit ON, remembering to account for the time display of the autostart.

The autostart trigger voltage level on the "plus-plus" line is adjustable with a potentiometer mounted on the control circuit board inside the ST-5000 cabinet. The potentiometer is located almost in the exact middle of the circuit board and can be identified as a 250k pot near the letters "AS" on the circuit board. This control is normally set at the factory to trigger the autostart on all signals giving a tuning meter reading of 0.6 and higher. The user may adjust this control to fit his own requirements. If the autostart sensitivity is set too close to the noise level, false printing may occur on noise or interfering signals; if set to too high a level, the autostart may not trigger on all but the strongest signals with exactly correct shift. Experience will determine the optimum setting for a particular system. Notice that the "plus-plus" voltage and therefore

autostart sensitivity are directly proportional to the degree of match between the signal tone frequencies and the center frequencies of the discriminator filters. It may therefore be difficult to set the autostart sensitivity and receiver tuning to respond to signals with improper frequency shift. Also, if the transmitter OR receiver should drift, the signal tones will soon no longer match the discriminator filters, causing the autostart to "shut-down." If drifting is a problem, the receiver should either be monitored often and manually retuned as required or the autostart should be switched OFF.

4.7 Tone Keyer Circuit

The ST-5000 includes a tone keyer that is very similar in design to the previous HAL model XTK-100 tone keyer board. All mark, space, and CW-ID tones are digitally synthesized from a type 555 IC oscillator. Unlike previous tone keyers, the ST-5000 CW-ID tone is generated at 100 Hz BELOW the mark tone instead of above. This further reduces the chances of falsely triggering the autostart of the receiving demodulator, even when 170 Hz shift is used. The tone keyer is driven from the loop derived FSK output signal. The tone output amplitude can be adjusted over the range of 0 to -40 dBm (approximately 1.0 V to 10 mV across 500 ohms) with an internal potentiometer. The amplitude is adjusted with the "OL" potentiometer, located on the rear of the circuit board. Although the output impedance of the tone keyer is 500 ohms, virtually any load impedance from 500 ohms to several megohms can be driven by the ST-5000. It is NOT necessary to terminate the audio output connector in a 500 ohm load.

4.8 Transmitting Radio Teleprinter Signals

As mentioned previously in section 4.3, radio teleprinter signals are generated by either shifting the transmitter RF frequency with the data (FSK) or by modulating the transmitter carrier with audio tones whose frequencies are shifted by the data (AFSK). Usually, FSK transmission is used for radio frequencies lower than 30 MHz and AFSK above 30 MHz. The ST-5000 can be used to receive AND transmit both FSK and AFSK types of signals.

4.8.1 Transmitting FSK Signals

There are two different techniques that are normally used to generate an FSK teleprinter signal. The simplest method involves direct shifting of the frequency of an oscillator stage in the transmitter. Typically, the data signal is used to turn on or off a diode switching circuit that effectively increases the oscillator tuned circuit capacitance on space, thus lowering the transmitter frequency for space condition of the data. A typical diode keyer circuit is shown in Figure 3.3. Note that the FSK data output is ideally conditioned for this application. Further information on this type of circuit can be found in a current edition of the Radio Amateur's Handbook (AARL, Newington, Conn.) or in the Radio Handbook (Ore, Howard W. Sams, Inc., Indianapolis, Ind.), or other text on radio transmitters. The standard radio amateur polarity convention is to make the mark frequency higher in frequency than the space frequency, although a number of exceptions are to be found, particularly in commercial applications.

A second technique to generate FSK uses a SSB type of radio transmitter. The AFSK tone output from the tone keyer is used as the audio modulation for the transmitter. Since a properly adjusted SSB transmitter suppresses one

sideband and the carrier of the AM signal, the RF output for a single frequency tone input is simply an RF carrier, displaced from the original carrier frequency by the tone frequency. When the tone frequency changes, the RF output frequency also changes by the same amount. Historically, the audio tone standard has been to designate mark as the lower frequency AUDIO tone and space as the higher. Thus, to achieve "normal" FSK RF output with mark as the higher RF frequency, the LSB (lower sideband) mode is used in the SSB transmitter (and receiver as explained in section 4.3). This technique is often mistakenly called the "AFSK-SSB" or simply "AFSK" method. However, the end result is exactly the same as if the transmitter were directly frequency shifted by the data and "FSK" is the true description of the RF signal generated.

At first glance, this SSB method is very attractive; it requires no internal modification to the transmitter and can use readily available SSB transmitters. However, there are a number of precautions that must be traced to the basic fact that SSB transmitters have been specifically designed to transmit voice signals and the performance and specifications are optimized for voice applications. The first conflict in specifications is in the duty-cycle rating of the transmitter. The duty-cycle of the typical voice is at best 50% (less compressors, etc.) while a RTTY transmission has a 100% duty-cycle. SSB transmitter power amplifier stages are usually designed to take advantage of the reduced duty-cycle of a voice signal to produce relatively high output powers in small enclosures with proportionally smaller power supplies. If the same SSB transmitter is operated in RTTY service at full voice ratings, the output amplifier and/or power supply will usually fail. Therefore, the SSB transmitter rating must usually be reduced by at least 50% when 100% duty-cycle RTTY transmission is used. There are a few commercially available SSB transmitters that will accomodate RTTY at full power, usually with the addition of a blower or heavy-duty power supply. The user should carefully check the rating of his SSB transmitter before using it in RTTY service.

Another problem often encountered when the tones are used with a SSB transmitter is very similar to the BFO-passband problem previously discussed in section 4.3.1. Since the SSB transmitter is designed to transmit the voice frequency range of 300 to 2400 Hz, it follows that some of the standard "high-tones" will NOT be transmitted, particularly the 2975 Hz space tone for 850 Hz shift. As with the SSB receiver, there are two ways to solve this problem, shift the carrier oscillator frequency with respect to the filter passband, or use lower frequency tones. The same procedure used to change the receiver BFO frequency can be used to change the transmitter carrier oscillator frequency. This may even be less convenient to do in the transmitter than the receiver since it usually involves changing a crystal in the transmitter. Use of the "low-tone" set of keyer frequency is always the simplest solution. However, use of the "low-tones" should be done with care for the following reasons:

1. SSB transmitters generally have no more than 55 dB of carrier rejection when properly aligned. If the balanced modulator has not been recently re-adjusted, the carrier rejection may well be no more than 25 to 35 dB. Transmission of a small amount of carrier with a SSB voice signal is not usually objectionable. However, when the SSB transmitter is used to transmit RTTY signals, the unsupressed carrier is now a spurious emission which is illegal

and may cause receiving problems. In general, the carrier supression and adjustment stability of a PHASING-TYPE of SSB transmitter is even worse and this type of transmitter should NOT be used to generate RTTY signals.

2. When the "low-tones" are used, the mark frequency is 1275Hz. If there is any distortion in the SSB transmitter audio or modulator, the second harmonic may be generated, causing radiation of still another spurious signal.

3. The present convention for AFSK-VHF transmission of RTTY signals in the United States is to use the "high-tones," 2125 Hz mark and 2295 or 2975 Hz space tones. A demodulator set-up for "low-tones" is NOT compatible with this application.

Conversely, if the transmitter carrier oscillator is shifted so that the standard "high-tones" can be used, the carrier rejection is greatly increased, audio distortion products generated in the transmitter do NOT fall within the transmitter filter passband, and the demodulator is then usable for BOTH FSK and AFSK applications. Note that 170 Hz shift with "high-tones" can be used without changing the transmitter carrier oscillator since both 2125 Hz (mark) and 2295 Hz (space) fall within the voice passband. However, the carrier rejection will be no better than it is for a voice transmission. Alternately, the following points FAVOR the use of the "low-tones:"

1. The current IARU international standards call for use of "low-tones."

2. The "low-tones" have been successfully used in commercial and military applications for some time with satisfactory results.

3. If the precautions noted above regarding carrier rejection and transmitter audio distortion are observed, the total system performance using "low-tones" can be just as satisfactory as a system using "high-tones."

The "optimum" choice between the two tone sets will vary with the application intended and the preferences of the user. It is hoped that the previous discussion will help alleviate some of the confusion that exists concerning the use of "low" vs "high-tones."

4.8.2 Transmitting AFSK Signals

Transmitting AFSK RTTY signals is much simpler than FSK signals. It is usually only necessary to connect the tone keyer output to the transmitter audio input, adjust the tone level, and transmit. Again, however, the duty-cycle rating of the transmitter should be considered. In particular, most VHF-FM transmitters are designed for intermitant duty and may NOT permit extended RTTY transmissions without reducing the transmitter power.

5. ST-5000 Circuit Description

Virtually all of the ST-5000 circuitry is constructed on a single circuit board which is then linked to the cabinet with plug-in connectors for rear panel connections, the motor relay, the loop resistor, and power transformer connections. The circuitry of the ST-5000 is illustrated in the block diagram of Figure 5.1, the schematics of Figures 5.3 and 5.4, and the layout drawings of Figures 5.5 and 5.6. Schematic diagram symbol conventions are shown in Figure 5.2. Refer to these diagrams for the following discussion.

5.1 Input Limiter Stage

The audio input tones from the station receiver are amplified and limited in operational amplifier I1, a type 709 with fast-response compensation. Additionally, two silicon diodes are placed across the input to prevent damage to the demodulator by very high-amplitude audio signals. This stage is similar to that used in both the earlier ST-5 and ST-6 demodulators.

5.2 Discriminator Filters

Separate mark and space discriminator filters are constructed of two high-Q active filters, one filter for each tone. These filters are specifically designed for broad band-width, linear phase response to assure optimum signal recovery in the face of noise as well as to minimize phase distortion of the signal. The mark filter center frequency remains constant for all selected shifts while the space filter center frequency changes with the shift switch. Two type 1458 dual operational amplifiers are used in the discriminator filter; the filters are patterned after those used in the HAL ST-6000 Demodulator.

5.3 Discriminator Detectors

The signals from the mark and space discriminator filters are detected in separate active detector circuits that use another 1458 IC (I4). The active detector circuit avoids the normal non-linearities and offset voltages of simple diodes and gives precision rectification of the AC signals over a wide dynamic range of input amplitudes, reducing the distortion on received signals as well as extending the dynamic range of receivable signals. The combination of the high-gain, wide-bandwidth limiter, the broad-bandwidth separate discriminator filters and the active discriminator detector circuits produces exceptional demodulator performance for a wide range of input signal amplitudes and distortion.

5.4 Meter Amplifier and Detectors

A portion of both the mark and space filters are also rectified by IN270 germanium diodes, filtered, and amplified by an emitter-follower (MPS3394). The resulting signal is of positive polarity for both mark and space signals, the amplitude depending upon the frequency match between the input signal and the discriminator filters. This "plus-plus" signal, as in the ST-6 and ST-6000, drives a tuning meter as well as the autostart circuit.

5.5 Active Low-pass Filter

Both sections of a 1458 are used in a three-pole active low-pass filter that follows the discriminator detector stages. The cut-off frequency of this filter is set to approximately 82 Hz to minimize noise on the signal while still allowing use of the ST-5000 at data rates up to 110 baud. This stage is similar in design to that of the ST-6 and ST-6000 demodulators.

5.6 Slicer Amplifier and Keyer Stages

One-half of a 1458 operational amplifier is connected as a high-gain clipping amplifier to produce fast rise-time keying pulses for mark and space conditions. The input of the amplifier can be switched for either inverting or non-inverting operation by the front panel SENSE (NORM - REV) switch, allowing the polarity of mark and space tones to be interchanged. The slicer directly drives a type 2N5655 high-voltage switching transistor which can then be connected to key the 175 VDC loop supply. The input to the 2N5655 can also be placed in a mark-hold condition by signals from either the autostart or standby circuits through the 1N4148 OR-gate diodes.

5.7 Autostart Stage

The "plus-plus" signal is a maximum when BOTH mark and space received tones match the center frequencies of the ST-5000 discriminator filters. This voltage is further integrated or "delayed" and then applied to half of a 1458 amplifier (16) which functions as a threshold detector. When a signal is correctly tuned-in, the "plus-plus" voltage goes to a maximum non-varying condition and gradually charges the electrolytic capacitor at the amplifier input. After 2 to 4 seconds, the threshold of the amplifier is exceeded, causing the output to go negative. This negative signal turns "on" two PNP dc amplifiers (MPS6518's), turning on the motor relay. When the RTTY signal is lost, the "plus-plus" voltage decreases, after 2-4 seconds the output of 16 goes to a plus voltage, putting the keyer stage into mark-hold through the 1N4148 diode. The input to the PNP relay drivers slowly rises as the electrolytic capacitor charges until the drivers turn-off, de-energizing the motor relay after 20 to 40 seconds. The Keyer stage can be put into mark-hold and the motor energized manually through the Remote Standby rear panel connection. Connecting the Remote Standby terminal to ground puts the keyer in mark-hold and turns-on the motor.

5.8 Tone Keyer Stages

The AFSK tones of the ST-5000 originate in a type 555 IC oscillator (17). The oscillator frequency (8 times the output frequency) is controlled by the 2700 pf silvered mica capacitor and the selected charging resistor. Types MPS3394 and MPS6518 transistors provide resistor switching for space or CW-ID data conditions. Different space resistor chains are selected by the front panel SHIFT switch to allow separate adjustment of each tone. As in the ST-6000, the CW-ID shift feature of the ST-5000 shifts the mark tone DOWN, rather than up, thus preventing false triggering of autostart circuits, especially with 170 Hz shift.

The pulse output of the 555 drives the 4024 counter (18) whose outputs are combined in exclusive-OR gate 19 (4030) to synthesize an 8-step sinewave approximation. A type 1458 (110) is then used as an active low-pass filter

to remove the harmonic components of the synthesized signal. The other half of I10 serves as an output amplifier stage. The gain of the amplifier is adjustable (OL=Output Level) to allow output amplitude adjustment over the range of -40 to 0 dBm.

5.9 Power Supply

The ST-5000 uses IC voltage regulators (I11 and I12) to produce the +12 and -12 volt supplies required for the operational amplifiers. A separate 175 volt, 60ma loop power supply is part of the ST-5000 demodulator. A voltage that varies from negative on space to positive on mark is derived from the loop supply with resistor dividers. This "FSK" voltage is controlled by the loop current and drives the AFSK tone generator and can be connected via the rear panel connector for a variety of applications as explained in section 3.4. Unloaded, the "FSK" signal may swing from -15 volts on mark to +15 volts on space; with loading, the voltage swing will be reduced.

The ST-5000 power transformer can be connected for either nominal 120 or 240 VAC, 50/60 Hz power line voltages. The 120 VAC connection is shown in Figure 5.4. To change a unit from 120 to 240 VAC operation, remove the jumpers from between transformer pins 1 and 3 as well as from between pins 2 and 4; add a jumper between pins 2 and 3. Do not change the other connections to the transformer. Note that the MOTOR accessory socket will provide the same voltage as that of the input power line.

5.10 User Adjustments

There are a total of eleven trimming potentiometers on the ST-5000 circuit board, most of which are factory adjusted and should NOT require further alignment. All controls are shown and labeled on the schematic and layout diagrams; the circuit board is likewise labeled with a two-letter abbreviation of the function name; for example, MS for Meter Sensitivity, AS for Autostart Sensitivity, and OL for Output Level. In general operation it should not be necessary to adjust any controls except these three - complete realignment should be performed by authorized personnel.

To set the Meter Sensitivity (MS control), tune a station in for a maximum meter deflection on the mark tone (1275 or 2125 Hz). Now adjust the MS control for a meter reading of 0.7 ma. Retuning the signal for space tone should again cause a meter deflection of 0.7 ma.

The Autostart Sensitivity (AS control) is set by first setting the MS control on the mark tone as described above and then detuning the receiver so that the meter deflection decreases to 0.6 ma. Control AS is now set so that the autostart just trips, indicated by monitoring the voltage output on pin 1 of I6 (test point E). The test point E will change from a high positive voltage (approximately +10 volts) to a similar negative voltage (-10 V) when the autostart activates. Either a zero-center voltmeter or dc oscilloscope can be used to monitor the test point.

The Output level (OL control) of the AFSK generator section should be set to produce the desired amount of modulation in the transmitter. If the desired setting of the control occurs at the lower end of the rotation, it is probably a good idea to use two resistors to make a 5 or 10:1 voltage divider of the AFSK output and then increase the control setting to compensate.

The other controls should not generally require alignment. It is particularly recommended that controls SB (Space Balance), WR (Wide Receive), NR (Narrow Receive), and MR (Mark Receive) not be adjusted since they are interacting adjustments that affect the discriminator filter adjustment. Control LB (Limiter Balance) adjusts the output of I1 (test point A) for zero volts dc with no input signal; controls MT (Mark Transmit), NT (Narrow Transmit), and WT (Wide Transmit) allow adjustment of the AFSK tone frequencies. Using a counter, adjust the mark tone first.

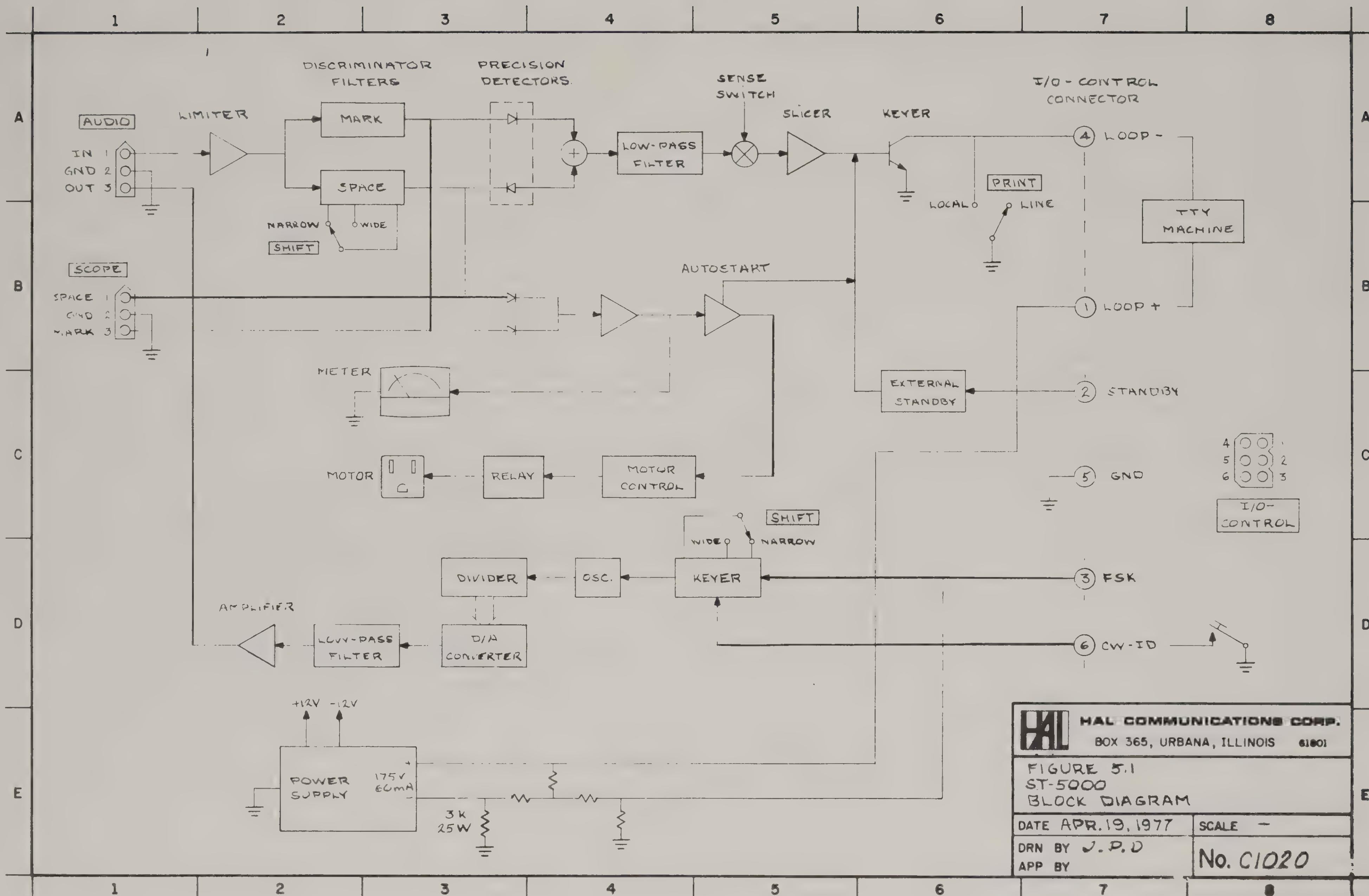

DISCRIMINATOR FILTERS
PRECISION DETECTORS
SENSE SWITCH
SLICER
KEYER
I/O - CONTROL CONNECTOR
AUDIO
IN 1
GND 2
OUT 3
LIMITER
MARK
SPACE
NARROW
WIDE
SHIFT
LOW-PASS FILTER
LOOP -
LOOP +
PRINT
LOCAL
LINE
TTY MACHINE
SCOPE
SPACE 1
GND 2
MARK 3
AUTOSTART
METER
EXTERNAL STANDBY
STANDBY
MOTOR
RELAY
MOTOR CONTROL
GND
4 5 6
1 2 3
I/O-CONTROL
SHIFT
WIDE
NARROW
DIVIDER
OSC.
KEYER
FSK
AMPLIFIER
LOW-PASS FILTER
D/A CONVERTER
CW-ID
+12V -12V
POWER SUPPLY
175V 60mA
3K 25W
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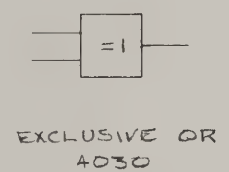
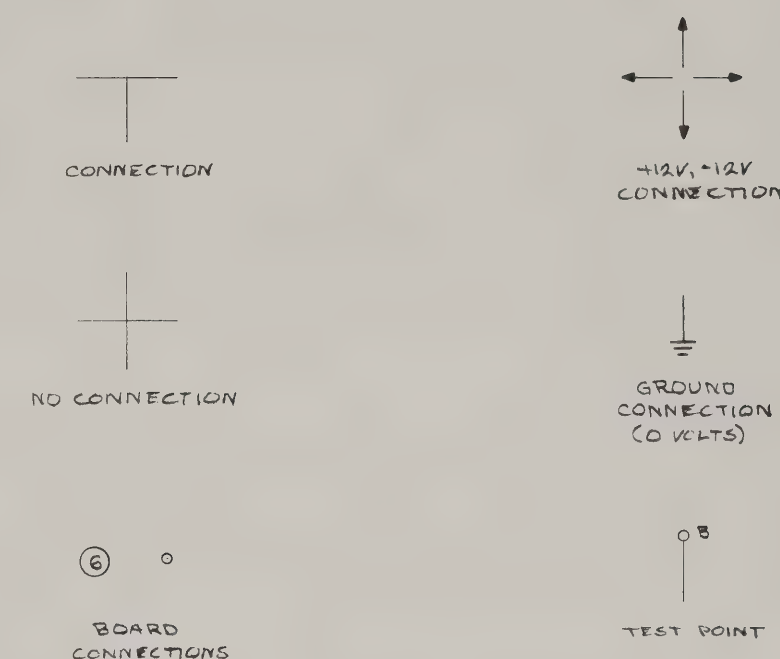
FIGURE 5.1
ST-5000
BLOCK DIAGRAM
DATE APR.19, 1977
SCALE –
DRN BY J.P.D
APP BY
No. C1020





NOTE: ALL RESISTORS ARE 1/4 W
UNLESS OTHERWISE SPECIFIED

ALL CAPACITORS ARE CERAMIC
UNLESS OTHERWISE SPECIFIED
MYL - MYLAR
SM - SILVER MICA
ELECT - ELECTROLYTIC

RESISTOR VALUES FOLLOWED BY:
H - DENOTES HIGH TONES (MARK = 2125 Hz)
L - DENOTES LOW TONES (MARK = 1275 Hz)

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FIGURE 5.2
ST-5000
DRAWING CONVENTIONS

DATE APR. 17, 1977	SCALE —
DRN BY J. R. D. APP BY	No. A1275

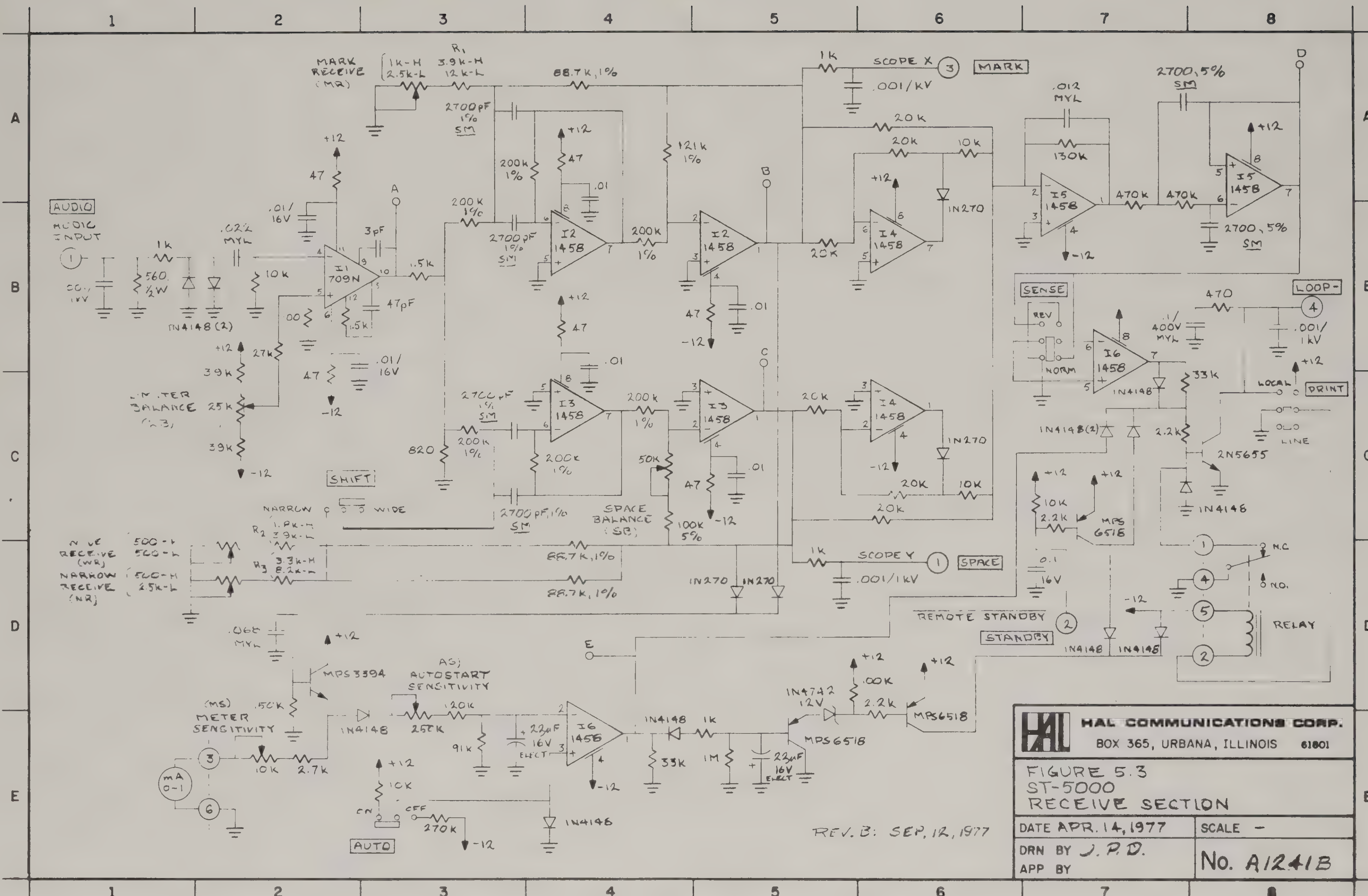
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FIGURE 5.3
ST-5000
RECEIVE SECTION
DATE APR. 14, 1977
SCALE -
DRN BY J. P. D.
APP BY
No. A1241B
REV. B: SEP. 12, 1977
AUDIO
AUDIO INPUT
MARK RECEIVE (MR)
LIMITER BALANCE
SHIFT
NARROW
WIDE
WIDE RECEIVE (WR)
NARROW RECEIVE (NR)
SPACE BALANCE (SB)
SCOPE X
MARK
SCOPE Y
SPACE
SENSE
REV
NORM
LOOP-
LOCAL
PRINT
LINE
RELAY
N.C.
N.O.
REMOTE STANDBY
STANDBY
AS) AUTOSTART SENSITIVITY
(MS) METER SENSITIVITY
AUTO
ON
OFF
mA 0-1
I1 709N
I2 1458
I3 1458
I4 1458
I5 1458
I6 1458
2N5655
MPS6518
MPS3394
1N4742 12V
1N4148
1N270

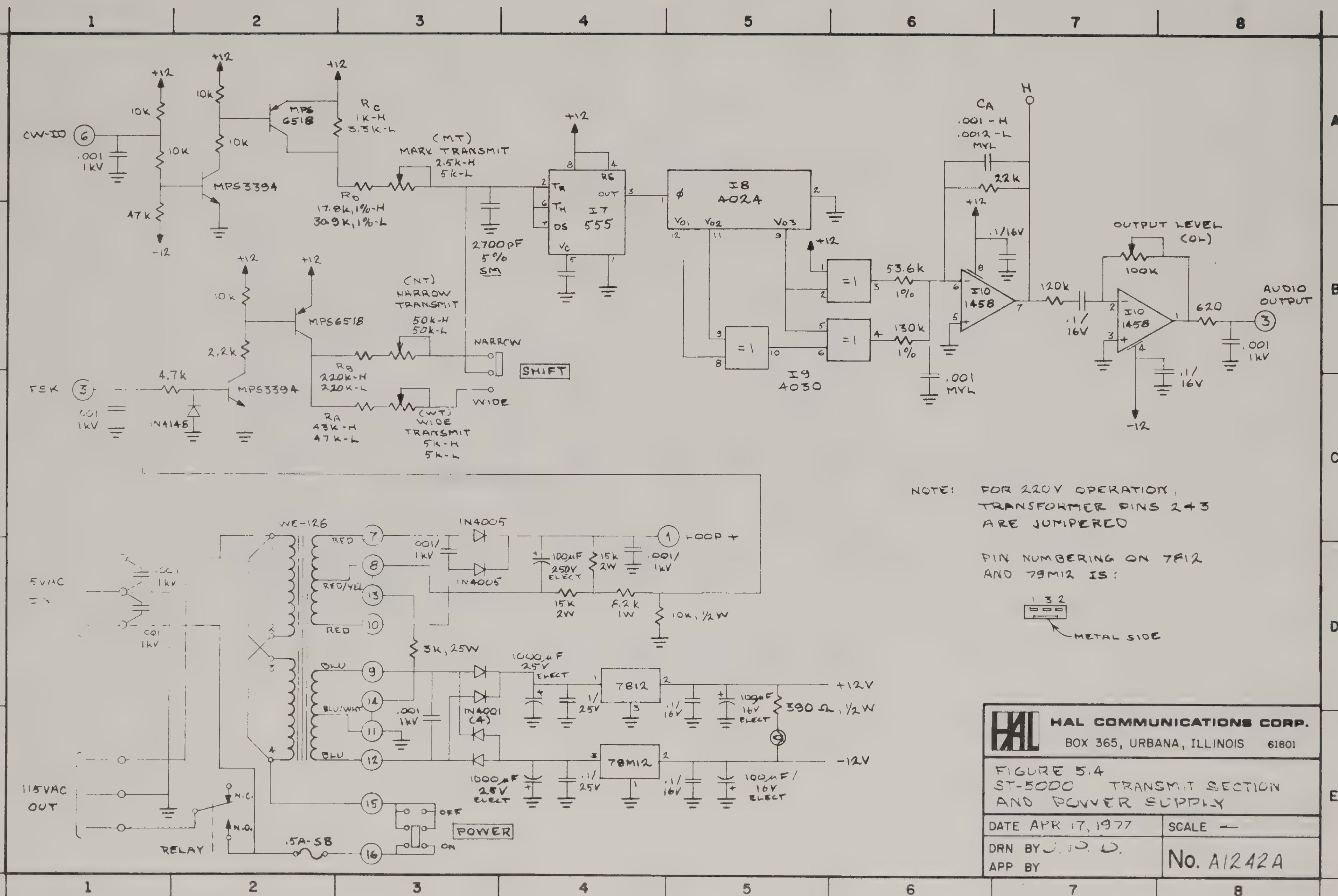
CW-ID
FSK
MARK TRANSMIT
NARROW TRANSMIT
WIDE TRANSMIT
NARROW
WIDE
SHIFT
I7 555
I8 4024
I9 4030
I10 1458
OUTPUT LEVEL (OL)
AUDIO OUTPUT
WE-126
LOOP +
115VAC OUT
RELAY
POWER
+12V
-12V
7812
79M12
NOTE: FOR 220V OPERATION, TRANSFORMER PINS 2 & 3 ARE JUMPERED
PIN NUMBERING ON 7812 AND 79M12 IS:
METAL SIDE
HAL COMMUNICATIONS CORP.
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FIGURE 5.4
ST-5000 TRANSMIT SECTION AND POWER SUPPLY
DATE APR 17, 1977
SCALE —
DRN BY J. P. D.
APP BY
No. A1242A

TRIM POTS

MR - MARK RECEIVE
1K-H, 2.5K-L

NR - NARROW RECEIVE
500-H, 2.5K-L

WR - WIDE RECEIVE
500-H, 500-L

MT - MARK TRANSMIT
2.5K-H, 5K-L

NT - NARROW TRANSMIT
50K-H, 50K-L

WT - WIDE TRANSMIT
5K-H, 5K-L

MS - METER SENSITIVITY
5K

AS - AUTOSTART SENSITIVITY
250K

SB - SPACE BALANCE
50K

CL - OUTPUT LEVEL
100K

RESISTORS

R_1 - 3.9K-H, 12K-L

R_2 - 1.6K-H, 3.9K-L

R_3 - 3.3K-H, 8.2K-L

R_A - 43K-H, 47K-L

R_B - 220K-H, 220K-L

R_C - 1K-H, 3.3K-L

R_D - 17.8K, 1%-H, 30.9K, 1%-L

CAPACITOR

C_A - 0.001 MYL-H, .0012 MYL-L

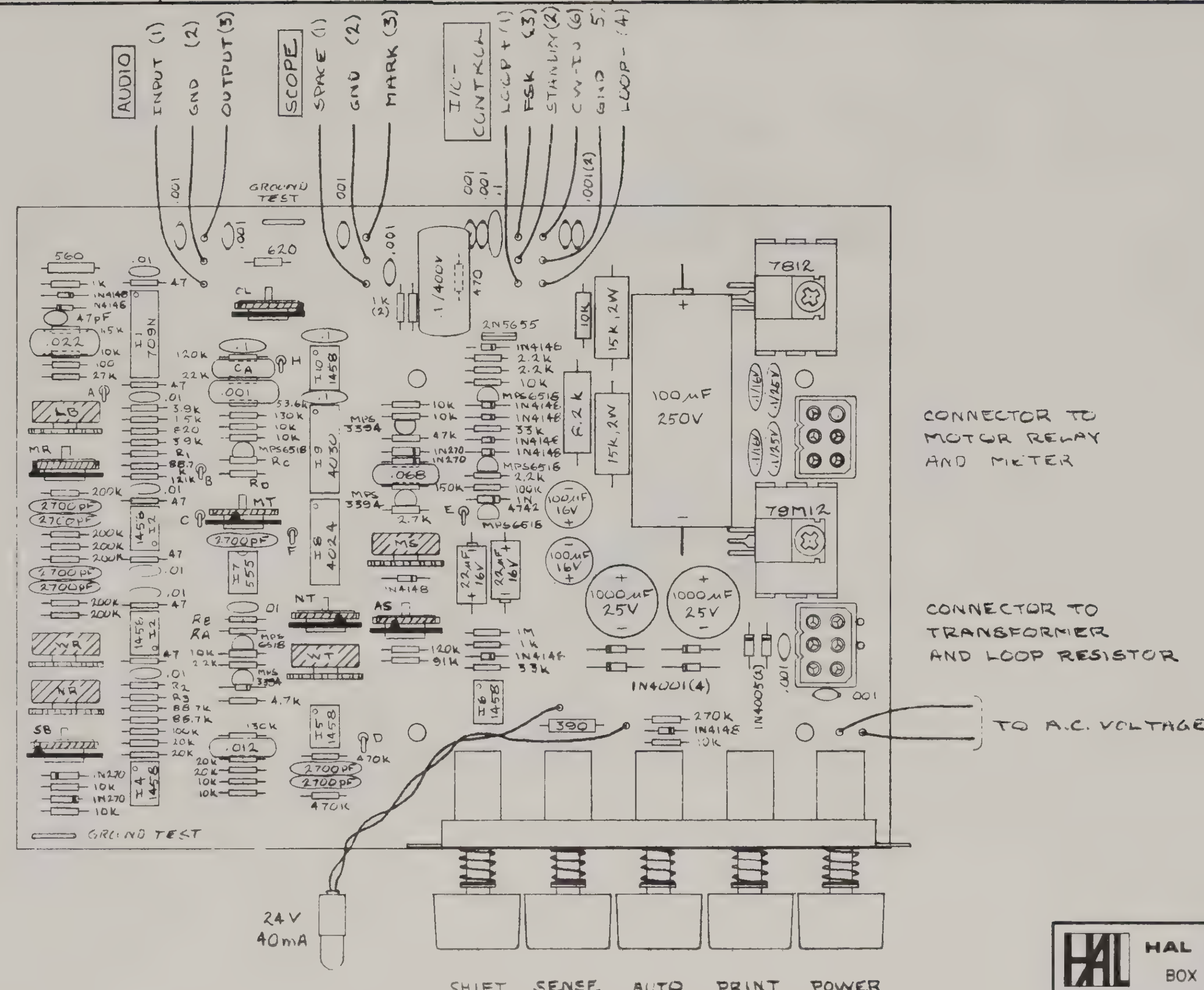

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FIGURE 5.5
ST-5000
CIRCUIT BOARD LAYOUT

DATE APR 25 1977	SCALE -
DRN BY	No. B1.48
APP BY	

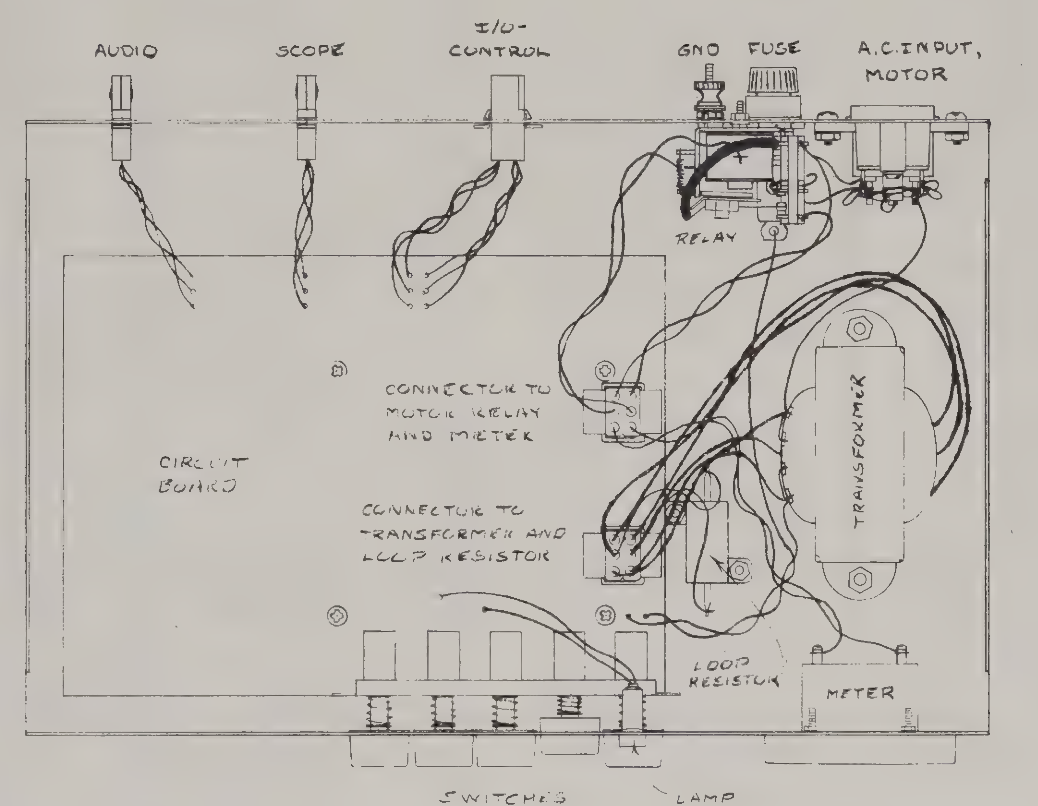

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FIGURE 5.6
ST-5000 CABINET
LAYOUT AND WIRING

DATE APR. 28, 1977	SCALE –
DRN BY J.P.D. APP BY	No. B1149

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P.O. BOX 365
URBANA, IL 61801

LIMITED WARRANTY

HAL Communications Corp. of Urbana, Illinois, hereby warrants to the original purchaser only that any new equipment manufactured by HAL Communications Corp. shall be free from defects in materials and workmanship for a period of one year from the date of original purchase. In the case of parts kits, this warranty applies only to materials and not to workmanship in kit assembly.

In the event of a defect in materials or workmanship during the warranty period, HAL Communications Corp. will, at its own expense, repair the defective unit and replace any defective parts. Costs of shipping the unit to HAL Communications Corp. shall be paid by the purchaser, as well as costs of removal and reinstallation of the unit. HAL Communications Corp. will bear the shipping costs incurred in returning the unit to the purchaser.

To obtain service under this warranty, the original purchaser should do the following:

1. Notify, as soon as possible, the Customer Service Department at HAL Communications Corp., Urbana, Illinois, either in writing or by telephone, of the existence of a possible defect;
2. At the time of notification, identify the model or serial number, the approximate date of purchase, the place of purchase, and the possible defect;
3. Hold the unit until a written return authorization is received.
4. Return the unit, freight prepaid, upon the receipt of the written return authorization.

Correct installation, use, maintenance, and repair are essential for proper performance of this product. The purchaser should carefully read the technical manual.

This warranty does not apply to any defect which HAL Communications Corp. determines is due to any of the following:

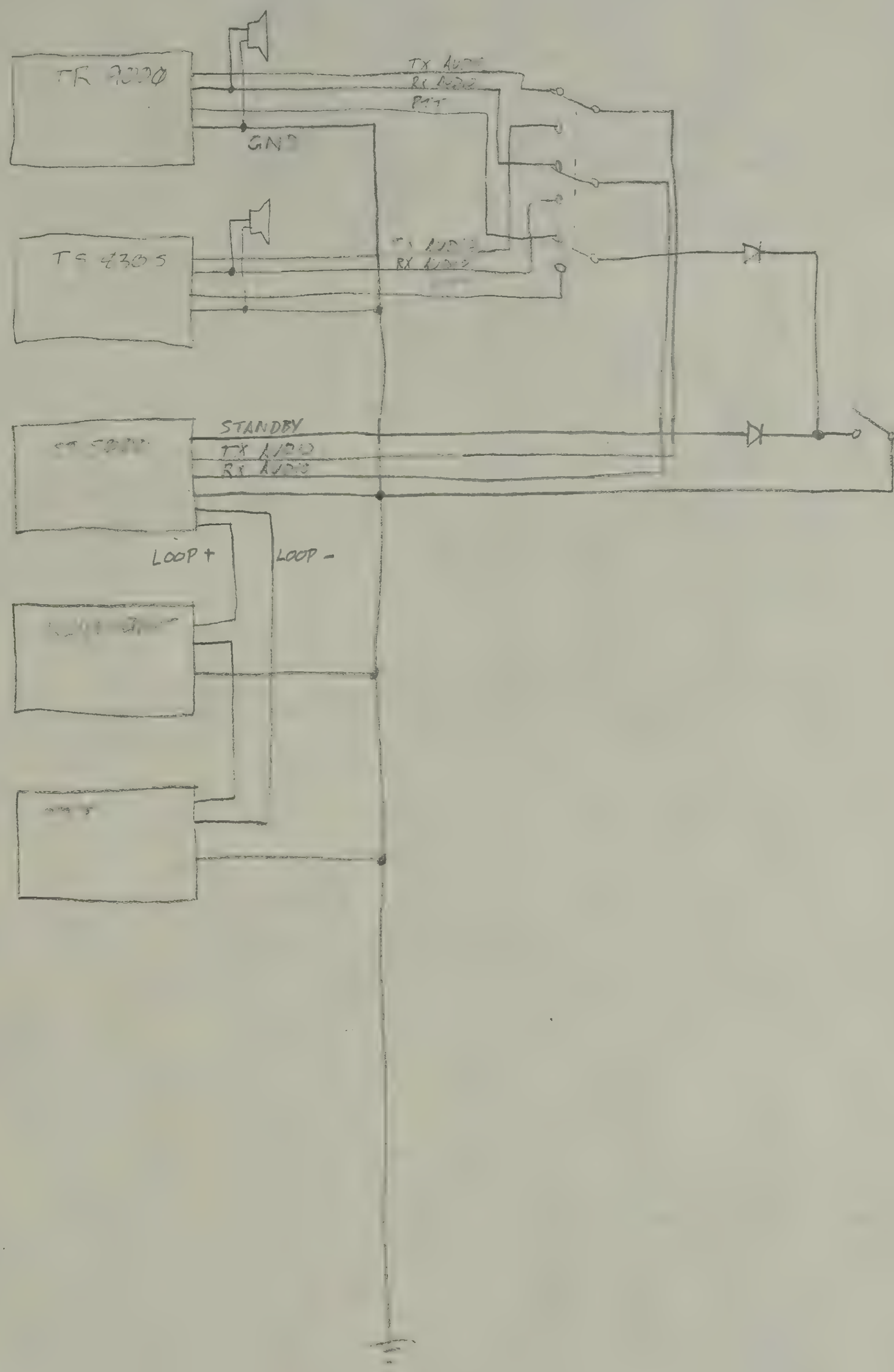
1. Improper maintenance or repair, including the installation of parts or accessories that do not conform to the quality and specifications of the original parts;
2. Misuse, abuse, neglect, improper installation, or improper operation (including operation without a proper safety ground connection);
3. Accidental or intentional damage.

All implied warranties, if any, are limited in duration to a period of one year from the date of original purchase. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

HAL Communications Corp. disclaims any liability for incidental or consequential damages arising out of the use of, or inability to use, this product. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

30 Kc


TS 430S
GND
STANDBY
LOOP +
LOOP -

SPECIAL CABLING INFORMATION

HAL COMMUNICATIONS CORP.

If you are making your own cables for interconnection of a HAL video terminal, HAL demodulator, and a radio transceiver (or transmitter/receiver separates), the following information may pertain to you.

The following transceivers, and possibly other similar rigs that contain solid-state switching circuitry, may require the circuit shown in Fig. 1 as part of the cabling between the transceiver and the HAL equipment:

<u>ICOM:</u>	<u>YAESU:</u>	<u>TEN-TEC:</u>	<u>KENWOOD:</u>
IC701	FT301	OMNI-D	TS-180
IC720	FT101ZD	OMNI-C	TS-120

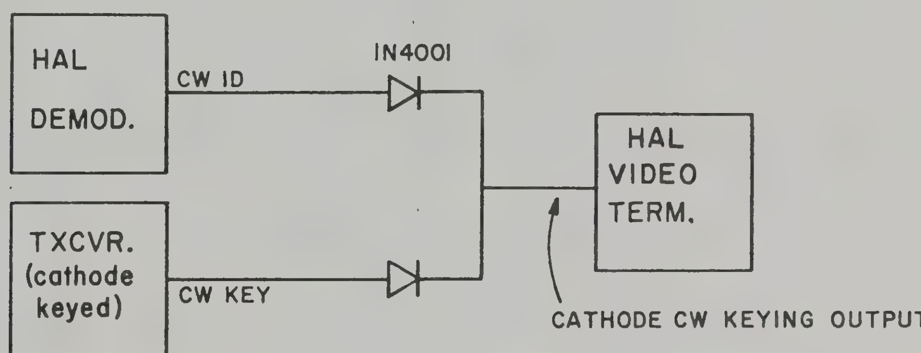


FIG. 1

Some transceivers, when used in systems containing the ST5000, may require the addition of the circuit in Fig. 2. If your system operates okay in CW, but will not receive when placed in the ASCII or Baudot mode, and disconnection of the transceiver mic plug corrects the problem, chances are that this circuit is required. The transceivers listed below require this circuit:

<u>YAESU:</u>	<u>ICOM:</u>
FT301	IC701
	IC720

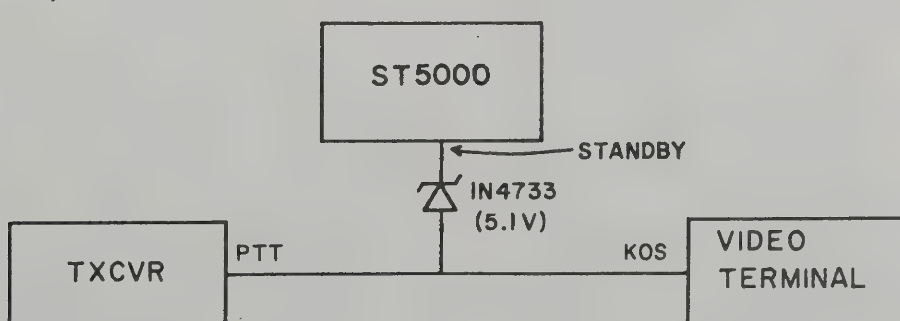


FIG. 2


BLUE
BLUE

HAL COMMUNICATIONS TECHNICAL MEMO 06171

1. RF-INDUCED PROBLEMS

HAL Communications equipment is designed to operate in close proximity to radio frequency transmitting and receiving equipment. Particular attention has been paid to the shielding of circuitry through the use of all-metal enclosures and good common grounds. However, under certain conditions in an rf-saturated environment, HAL equipment may be susceptable to rf-induced interference. This may manifest itself in any of a number of ways, such as partial or complete lack of response to operator commands, or erratic behavior of a video display..

The first thing that should be checked if rf problems are suspected is the ground system. The transmitter should be properly grounded for rf (in addition to electrical ground) and all other station equipment grounds should be connected to the transmitter chassis. The rf ground should consist of a short length of heavy copper wire or braid terminated at a good earth ground (ground rod or copper cold-water pipe). If a water-system ground is used, be sure that the pipes are 100 percent metal from the point of connection to the water mains -- plastic plumbing will break the ground path. If the distance between your transmitter and ground rod or water-main ground is more than a quarter wavelength at the highest operating frequency, make the ground wire a half wavelength, or a multiple of a half wavelength long. If you plan to operate on 10 and 15 meters you may need to run a separate ground wire for each band if the distance requires the use of half-wavelength wires. For example, if the distance from the ground point exceeds about 8 to 10 feet, a 10-meter half-wave ground wire (16 feet long) and a 15-meter half-wave ground wire (22 to 23 feet long) would be used. Consult any of the amateur handbooks or antenna books for a more in-depth discussion of grounding techniques.

The best way to confirm that a problem is being caused by rf induction is to temporarily eliminate the source. This may be done in stages, starting with a partial reduction in exciter drive, and ending with transmitter shut-off. Since rf energy can be induced in the demodulator or video terminal circuitry through several different paths, connecting the transmitter to a dummy load may not eliminate all rf related problems, although this is an excellent first step in verifying rf problems.

Radiation of rf energy from linear amplifiers, antenna tuners, coaxial switches, monitor scopes, and interconnecting coax-cable jumpers is also possible. In fact, it is this type or radiation that is most likely to be coupled into nearby I/O and power cables going to HAL equipment. To locate the point or points of radiation, experiment with different cable arrangements to see if the rf-induced problem can be eliminated by reducing coupling between any of the HAL cables and nearby coaxial lines carrying rf power. Fig. 1A contains several cable arrangements, both bad and good, showing how to keep rf coupling to a minimum. The drawing in Fig. 1B shows the use of high-mu (950 or 2000) ferrite toriods or rods to choke the flow of rf on audio and control lines.

If cable rearrangement doesn't yield positive results, then begin eliminating pieces of equipment and sections of coaxial cable until the transmitter is connected directly into a shielded dummy load. As each piece of equipment is removed from the transmission line, check to see if the rf-related problems have diminished or disappeared. If the rf problem persists with the

RF-INDUCED PROBLEMS (CONT.)

exciter connected directly to a dummy load reduce the drive level to see if that eliminates the problem.

If operation into a dummy load does not significantly reduce the rf-related problems, disconnect all I/O cables from the affected piece of HAL equipment. Test operation of the unit while it is connected only to ac power. At the same time, enable the transmitter so that it sends a CW signal into a dummy load. If rf problems are still present, then rf energy is probably being introduced to the HAL equipment circuitry through the power cord by means of the common ac power line. This is usually indicative of poor ac-line filtering in the radio transmitter power supply section. Fig. 2A shows a common bypass-filter method used in many transmitters. The drawing in Fig. 2B depicts a brute-force ac-line filter that can be added to transmitters or other equipment to eliminate the flow of rf on power lines.

Rf-induced problems that cannot be cured, or ones that appear not to be the fault of inadequate transmitter filtering should be referred to HAL factory Customer-Service personnel. In cases where this is not feasible, or where station rearrangementis necessary to affect complete elimination of rf problems, the information in the following section may be of some help.

2. MINIMIZING RF-RELATED PROBLEMS THROUGH ANTENNA SELECTION

In addition to the liberal use of rf bypassing capacitors on station equipment, the use and deployment of certain antennas will offer reduced levels of rf in the radio room in many cases. Whenever possible, use <u>resonant</u> Yagi, quad, dipole, or vertical antennas. Try to achieve a good impedance match <u>at the antenna</u> instead of relying on an antenna tuner. Random-length wire antennas and others that require tuning from the shack are more likely to create high levels of rf within the vicinity of the operating position.

The location of the transmitting antenna with respect to the radio room also has an effect on the rf energy that is coupled into interconnecting cables. Apartment dwellers may have the most difficulty achieving a good installation since many times an indoor antenna is the only type allowed. When this is the case, locate the antenna as far away from the operating position as possible. Where outdoor antennas are allowed, they should be placed as high as practicable. Not only will this provide optimum reception, but it will also reduce the level of rf in the shack -- all other factors being constant. Excellent antenna installation information can be found in radio & electronics handbooks and antenna theory and construction booklets, as well as in articles published in electronics periodicals.

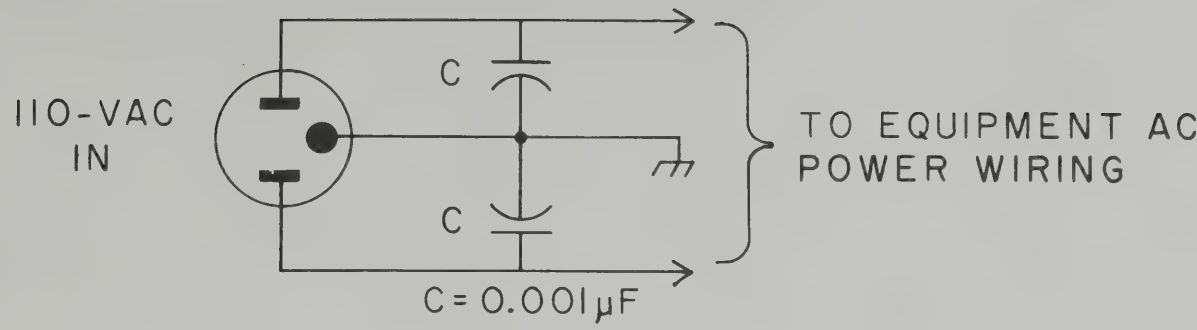
In most situations, coaxial cable feed line is preferred over open-wire, twin-lead or single-wire type feed systems as its self-shielding property reduces the chance of unwanted rf coupling.

ANTENNA SELECTION (CONT.)

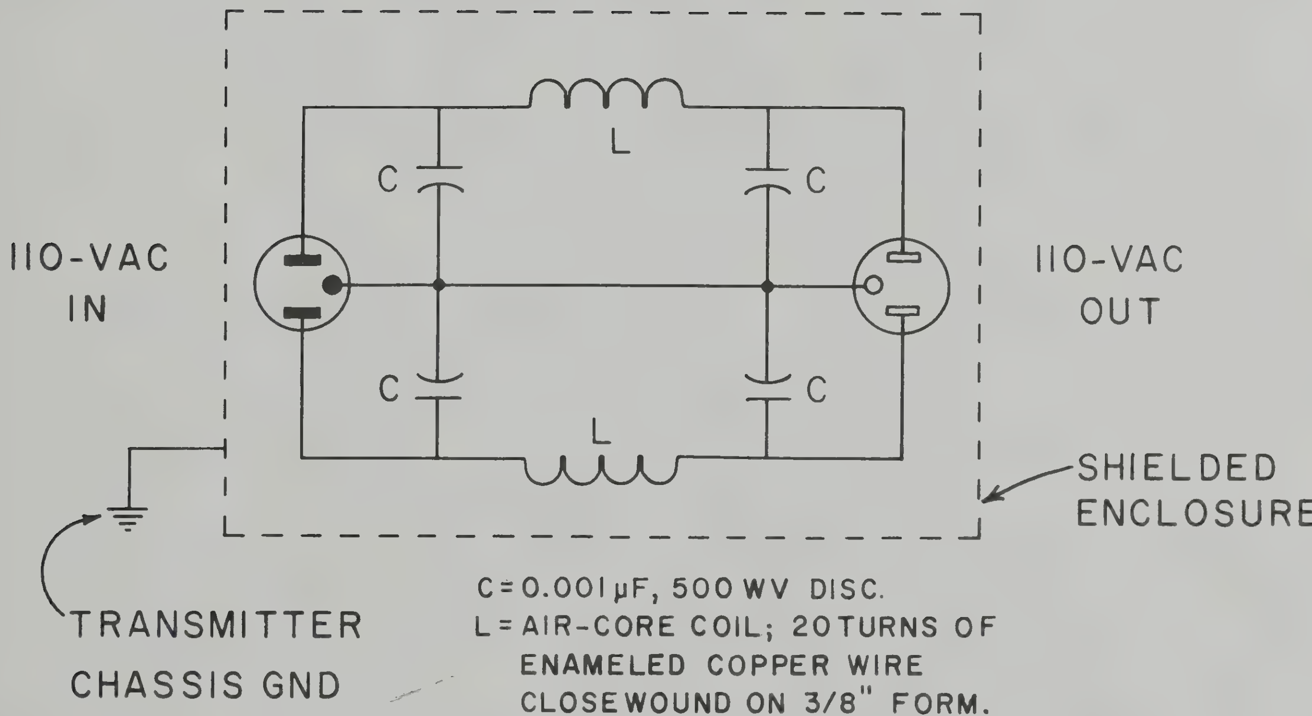
Rf energy may also be conducted back to the station by coupling of rf between the antenna and the outside shield braid of the coaxial cable feed. The use of a balun on a center-fed dipole fed with coaxial cable may also help reduce coupling, and therefore reduce interference. An rf choke constructed by winding five or six turns of coaxial cable in a coil approximately six inches in diameter may also help reduce the flow of rf currents on the outside of the coaxial-cable braid. If such a choke is used, it should be wrapped with electrical tape to hold the windings together, and be secured as close as possible to the feed point of the antenna.

Try to dress the coaxial cable feed lines so that they drop perpendicular to the antenna wire, and not parallel to the radiating portion of an element. In some cases, it may be necessary to run the coaxial cable straight to the ground and bury it for the run to the transmitter to reduce the coupling between the outside shield braid of the coaxial cable and the antenna. If there is a moderate SWR on the line, try adjusting the coaxial cable length so that a low impedance (high feed current) is presented to the transmitter. This may help reduce the level of rf in the vicinity of the transmitter.

###

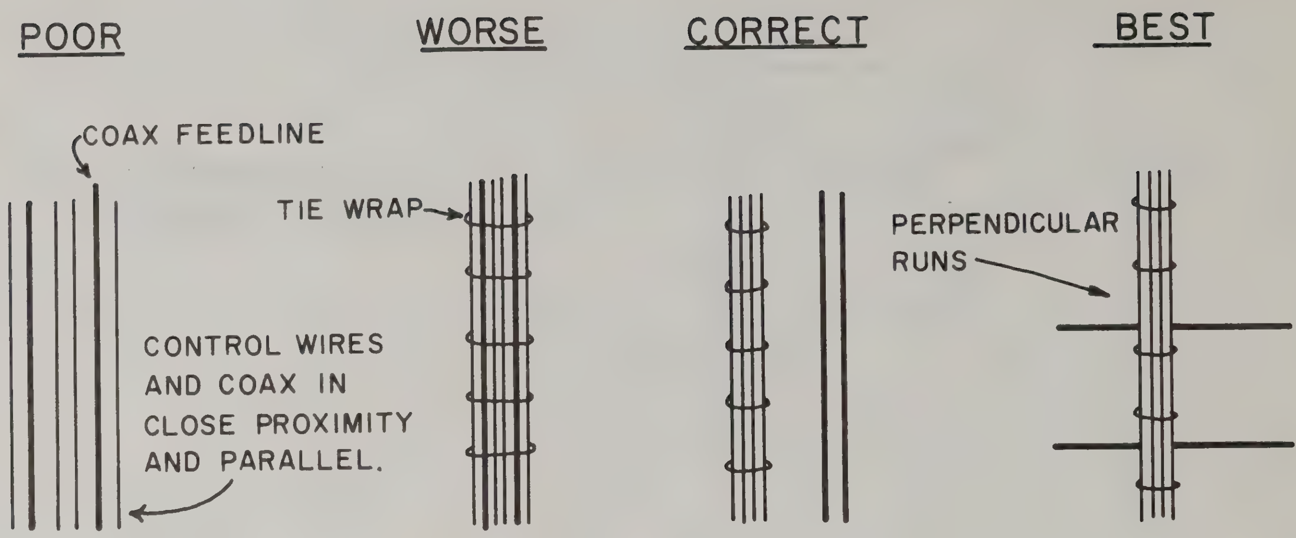


(A)



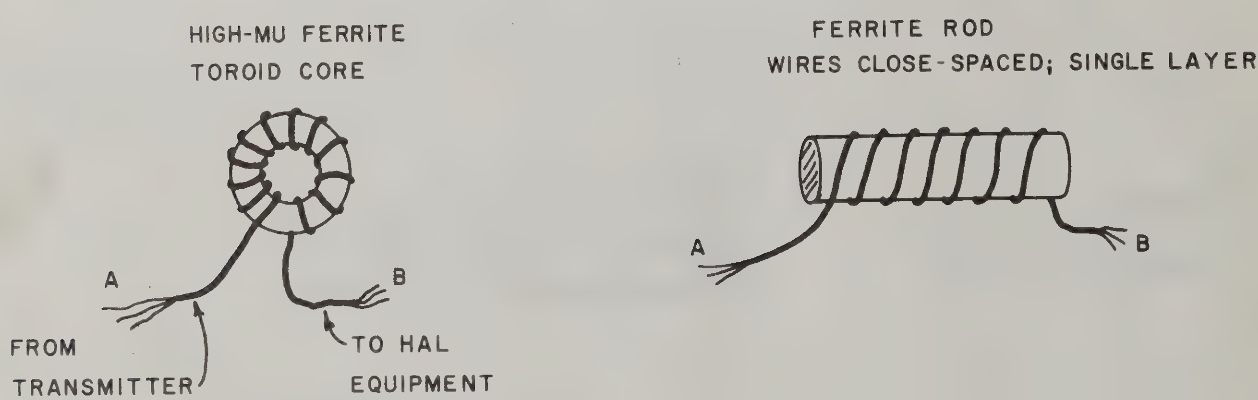
(B)

FIG. 2 -- (A) Simple rf-bypass method used in many transmitters.
(B) Brute-force ac-line filter that can be added to reduce or eliminate the flow of rf on the power line.



(A)

PLACE RF CHOKE CLOSE TO REAR PANEL OF EQUIPMENT



(B)

FIG. 1 -- (A) Cable arrangements, showing ways to reduce rf coupling.
(B) Use of high-mu ferrite toroids and rods to choke the flow of rf on audio and control lines.

HAL COMMUNICATIONS CORP.

AUTUMN, 1980
AMATEUR RADIO CATALOG

HAL COMMUNICATIONS CORP.
BOX 365
URBANA, IL 61801
217-367-7373

ANSWERS TO OFTEN-ASKE

"WHY WORK RTTY?"

RTTY is one of those quickly growing "specialized" forms of amateur communications. The attraction to its devotees is probably a mixture of the magic of modern digital communications coupled with the convenience of written rather than coded or voice communications. If you participate in the popular autostart nets, it's not even necessary to be home when receiving a RTTY message—the printer or display will record the text for you to read at your convenience. RTTY is very popular among "rag-chewers" and "engineers" alike; in fact, you get to do a bit of both. The rapid growth of digital electronics has carried over to both RTTY and the new home computer hobby. ASCII communications between ham computers lacks only final FCC approval. If your "bag" is chasing DX, what could be more satisfying than a DXCC certificate for all RTTY? There are several DX RTTY contests sponsored every year with heavy participation. So, rather than ask "Why?" ask "How?"

"WHAT DO I NEED TO WORK RTTY?"

A ham RTTY station needs a transmitter, receiver, and antenna just like any RF communications system, in addition to some "special boxes" to make the RTTY part work. Some considerations for the equipment are outlined below:

1. RECEIVER - TRANSMITTER

   The RTTY receiver and transmitter (or transceiver) should be stable, well calibrated, and capable of *EXTENDED TRANSMITTER OPERATION*. When you are transmitting RTTY, the full carrier is on for longer periods of time than for CW or SSB voice. So, check your manual and manufacturer for RTTY specifications and, if in doubt, reduce transmitter power somewhat. For HF work, a good SSB rig in LSB mode works well with RTTY tones (more on tones, later). Most VHF-FM transmitters work with RTTY, but avoid overloading the transmitter as mentioned above.

2. ANTENNA

   A good antenna will buy you the same benefits in RTTY as it does in other modes. One caution though, the traps on some antennas may not handle as much power in continuous RTTY operation as they do for CW or SSB voice. This can especially be true of trap yagi antennas for the HF bands.

3. RTTY DEMODULATOR

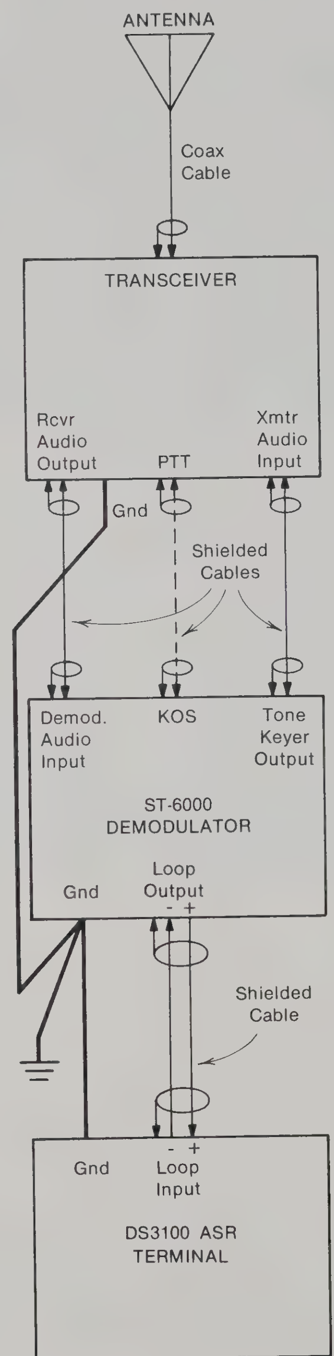
   The demodulator connects to the receiver audio output and converts the RTTY tones to keying pulses. The quality of your printed signal is determined more by demodulator performance than by any other portion of the system. Demodulators come in all shapes, sizes, and prices. HAL offers the feature-packed ST-6000 with active filters, scope, autostart, anti-space, ATC, DTH, and KOS, as well as the lower cost ST-5000. The popular ST-5 and ST-6 parts kits are also still available for the skilled technician.

4. TONE KEYER

   The tone keyer circuitry converts the keying pulses from your keyboard into audio tones to drive the transmitter. Since this circuitry is closely related to that of the demodulator, both are supplied in the same cabinet in all HAL demodulators.

5. TERMINAL

   The terminal is the device that prints or displays the received signals while allowing you to type your transmitted message. The terminal is sometimes divided into a keyboard and a printer or display section. The terminal can be as simple as an old surplus TTY machine or as exotic as the microprocessor controlled HAL DS3100 ASR terminal. An important feature of HAL Communications terminals is that ALL HAL RTTY EQUIPMENT IS LOOP COMPATIBLE WITH TTY MACHINES. This means that you can add HAL electronic equipment to your RTTY system at any time. The advantages of the HAL electronic terminals are many; ranging from lack of noise and oil (keeps the XYL happy and your nerves soothed) to automatic operator features such as real-time editing of typing errors, programmable identification message, and automatic carriage return/line feed operations. Also, the speed of the electronic terminal is easily changed with a front-panel switch. Machines require an expensive gear box or a manual change of gears to change speed. HAL offers the DS3100 ASR and the new DS2000 KSR terminals. The DS3100 ASR, DS2000 KSR, and the earlier DS-3000 KSR all work the standard ASCII computer code as well as the normal amateur BAUDOT code.



"HOW DO I HOOK IT UP?"

Probably the most frightening thing to the RTTY beginner is the thought of all those wires that must be connected to make it work. A particularly complicated RTTY station can have a real "rats-nest" of wires, but it didn't start that way. Make connections in a logical and step-by-step manner and all will work well. All transceivers are slightly different, but, in general, you will have to make these connections:

1. GROUNDING

   Before making any other connections, decide approximately where your equipment will be located and run short, low-inductance ground wires (shield braid recommended) between the cabinet grounds of all equipment AND MACHINES. Do not defeat the AC safety ground on the HAL power cords; run separate RF grounds in addition to the AC safety ground. *LACK OF ADEQUATE RF AND SAFETY GROUNDS CAUSES MORE PROBLEMS IN RTTY INSTALLATION THAN ANY OTHER SOURCE.*

2. RECEIVER TO DEMODULATOR

   Use shielded cable to connect a 500 ohm audio output of the receiver to the demodulator audio input jack. If you do not have a 500 ohm output, the 4-8 ohm speaker output will work, but not as well; a speaker to 500 ohm line transformer would be a good part to add when possible.

3. TONE KEYER TO TRANSMITTER

   Use shielded cable to connect the tone keyer output of the demodulator to the transmitter audio input. Often, a rear-panel "phone-patch" or "auxiliary" input is provided. If not, connect directly to the microphone connector.

4. DEMODULATOR TO TERMINAL

   Use shielded cable to connect the terminal to the demodulator. Use the current loop connection for each. When connecting to a solid-state terminal, be sure to observe the proper polarity as indicated in the operator's manuals. Be extremely careful when wiring the loop circuit—potentially lethal voltages are present when the equipment is turned on (200 VDC @ 60 ma). Also, be sure that no part of the loop circuit is connected to chassis ground in machines or other equipment. All RTTY equipment is connected in series when the current loop output is used.

5. CONTROL CIRCUITS

   Since the control requirements differ with manufacturer, study your transceiver manual carefully to determine how to control the transmit-receiver function. Usually, you can control the push-to-talk (PTT) line through a pin on the microphone connector, a front panel switch, or a rear panel accessory connector. Initially, try to manually switch between transmit and receive until you are familiar with RTTY operation. Eventually, you will probably want to take advantage of the automatic Keyboard Operated Switch (KOS) feature of the DS3100 ASR and ST-6000. KOS is the RTTY equivalent to VOX; typing on the keyboard puts you into transmit mode. If you pause long enough, the KOS "drops-out" putting you back into receive mode. KOS is particularly convenient for short exchanges.

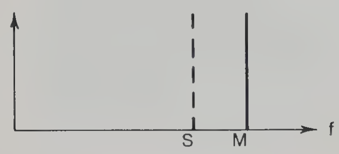
"WHAT IS THIS MARK AND SPACE BUSINESS?"

The RTTY signal from the terminal is a series of pulses. The amateur BAUDOT RTTY signal has 7 possible pulses for each character typed or printed, each transmitted one-after-another (serial). Each pulse can be either "ON" (current flow in the RTTY loop) which is called "MARK" or "OFF" (no current flow), the "SPACE" condition. To keep decoders synchronized, the first pulse of a character, the START pulse, is always a SPACE (current off); the last pulse, the STOP pulse, is always a MARK (current on). The 2nd through the 6th pulses can be either MARK or SPACE, depending upon the coding required for a character. The START and all 5 data pulses are the same length; the STOP pulse may be either equal to or longer than the others. The so-called computer ASCII code uses START and STOP pulses but has eight instead of five intermediate data pulses, thus allowing a greater number of characters to be encoded. Although all machines and HAL electronic terminals use pulses, the MARK and SPACE pulse conditions are converted into MARK and SPACE audio tones for easy radio transmission.

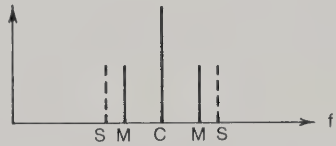
QUESTIONS ABOUT RTTY

"WHAT IS THE DIFFERENCE BETWEEN FSK AND AFSK?"

Transmitting RTTY signals via radio could be done like Morse code with on-off keying of the transmitter carrier. However, the interference received during off-times would give badly distorted printout. Rather, HF RTTY is transmitted with Frequency Shift Keying (FSK) so that the mark pulse condition corresponds to one radio frequency and the space to another. Amateur radio convention has it that the mark radio frequency is higher than space and that the separation or "shift" of the signal is standardized at 170 Hz or 850 Hz. (425 Hz shift is also used by commercial RTTY stations.) Most present-day amateur RTTY stations use 170 Hz shift exclusively. The FSK signal is received with the BFO turned on, giving two audio frequency tones for the mark and space conditions. The audio tones are, in turn, detected in the demodulator and the resulting pulses drive the display or printer. Note that changing the transmitter or receiver frequency (on purpose or through frequency drift) will change the audio output frequency to the demodulator. The HF system is therefore quite drift sensitive. Present HF equipment frequency stabilities are quite adequate for FSK RTTY, but it is only very recently that VHF equipment was available with similar stability. Therefore, VHF RTTY has traditionally been transmitted by first keying audio tones with the RTTY pulses and then using these tones as the audio modulation of an AM or FM VHF transmitter. This is called AFSK for Audio Frequency Shift Keying. Current amateur convention is to make the mark audio frequency lower than the space frequency by the amount of the shift. Since the RTTY data is audio modulation of the carrier, frequency drift of either transmitter or receiver is a lot less critical. The audio frequency of the tones transmitted is set to be the same as those in the receive demodulator.

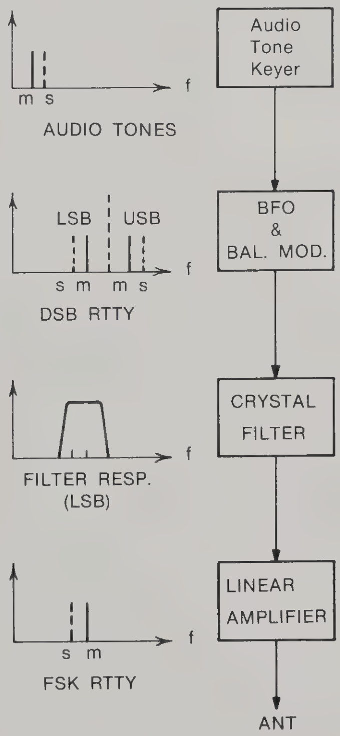


FSK RTTY



AFSK RTTY (AM)

The required radio frequency shift keying can be done in two different ways: shift the frequency of a transmitter oscillator directly with the RTTY pulses or use a SSB transmitter with audio tones. Direct FSK keying circuits are described in most amateur journals and are generally simple, but require modification of the equipment; generation of FSK with a SSB transmitter is as follows: If a Lower Sideband Transmitter (LSB) is driven with a 2125 Hz audio tone, the RF output of the transmitter will be at a frequency 2125 Hz *BELOW* the suppressed carrier frequency. A properly adjusted LSB transmitter will have *NO OTHER* output frequencies. If the input tone is changed to 2295 Hz (170 Hz shift), the RF frequency is now 2295 Hz BELOW the carrier frequency. Thus, audio tones into the LSB transmitter have produced FSK carriers out of the transmitter. Note that, because the LSB mode was used, the 2125 Hz standard mark tone for VHF AFSK has become the higher radio frequency. Thus, the same demodulator and tone keyer can be used for both VHF AFSK and HF FSK operation. Often, this use of audio tones with a SSB transmitter is mistakenly called "HF AFSK"—actually the resulting output is true FSK, IF the SSB transmitter has no spurious outputs (such as carrier or unwanted side-band). Most HF RTTY amateur radio stations use audio tones with a SSB transmitter. Although "standard" audio tones for VHF amateur operation have long been 2125 Hz for mark and 2975 Hz for space (850 Hz shift), limited audio frequency response of HF SSB transmitters and receivers has recently given rise to a second set of "standard" tones at lower frequencies ("Low-tones").



"HOW ABOUT HIGH- VS LOW-TONES?"

Historically, demodulator tones were set to 2125 Hz for mark and 2975 Hz for space reception of 850 Hz shift. When transmitter stability improved, 170 Hz shift was used and the space frequency changed to 2295 Hz (mark remained at 2125 Hz). These three tones were, and still are, a standard for U.S. Amateur RTTY. However, in the early 1960's, virtually all commercially available transmitters and receivers became filter-type SSB equipment with audio pass-band limited to speech frequencies, sometimes as narrow as 2.1 kHz (300 to 2400 Hz). Obviously, the 2975 Hz (850 Hz shift Space) tone will not pass-through such a filter and 850 Hz shift with these tones is not possible (although the 170 Hz shift is). Therefore, either the SSB equipment must be modified or different, lower-frequency tones must be used if 850 Hz RTTY shift is desired. Both approaches have their advantages and both are currently in use. The so-called "LOW-TONE" standard sets mark at 1275 Hz and space at 1445 Hz (170 Hz shift) or 2125 Hz (850 Hz shift), conforming to the European IARU standard. So, there are now two sets of "standard" tones, LOW and HIGH (as well as a myriad of others), all of which work *INTERCHANGEABLY* on HF RTTY. However, since the actual audio tone is transmitted for VHF AFSK operation, the two sets are *NOT COMPATIBLE IN VHF AFSK* applications. Current U.S. Amateur operation uses the HIGH TONES for VHF. Thus, to use a demodulator and keyer for both HF and VHF operation, it should be set-up for HIGH-TONE operation. Conversely, you may wish to have separate stations for HF and VHF, simplifying the cabeling, and providing simultaneous monitor/operation capability, as well as resolving the tone problem. The HAL ST-6000 and ST-5000 Demodulators are available for either HIGH or LOW-TONE operation.

"WHAT FREQUENCIES DO I USE FOR RTTY?"

HF RTTY Operation has evolved to heavy operation on the 80 and 20 meter bands (CW segments) with sporadic operation on other HF bands. 80 meter RTTY stations tend to operate between 3600 and 3650 kHz and 20 meter stations between 14.075 and 14.100 MHz. 170 Hz shift is used almost exclusively with mark being the higher radio frequency. 60 wpm (45 baud) is the most popular RTTY speed, but 100 wpm (74 baud) is gaining in popularity.

VHF RTTY operation in most areas is concentrated on 2 meter FM with 146.700 MHz being the popular operating frequency. Virtually all stations are now using the "High-tones," usually with 170 Hz shift. As with HF RTTY, 60 wpm (45 baud) is most popular on VHF. Some areas now have RTTY-only repeaters on 146.10/146.70 MHz.

"WHO DO I TALK TO ON RTTY?"

RTTY enthusiasts run the full range of ages and interests, but tend to be technically inclined. The typical RTTY'er is always modifying his station, likes to talk, and usually has more ideas than you have printer paper (or display screen)! Some operators are good typists; most aren't. The DS3100 ASR letters-fill and editing modes make even a poor typist look good. Recently, the home computer hobby has become quite popular with RTTY people and you may find a lot of help in debugging your programs if that's your interest. There are an increasing number of DX stations on RTTY.

"HOW MUCH DOES IT COST?"

RTTY is like any other hobby—it can cost as much or as little as you want it to. If you buy used machines and build kits or your own designs, the total RTTY cost can be quite low. Conversely, the DS3100 ASR and ST-6000 offer an *ULTIMATE* RTTY station that is expensive. Because all of the HAL RTTY products are current loop compatible, you can add devices as your interests (and pocketbook) indicate. For the beginner, HAL has the following recommendations:

1. DEMODULATOR
   Assuming you already have a good transceiver and antenna, your first major RTTY purchase should be a good demodulator. The HAL ST-5000 makes a particularly good, cost-effective unit. If you select a high-tone ST-5000, it will be usable for either VHF or HF (170 Shift) RTTY operation; if you are only interested in HF RTTY (for short-wave-listening to press stations, for example), the low-tone unit may be a better choice. Conversely, you may wish to "jump-in" and get the ST-6000 from the first. Either way, put high priority on a *GOOD* demodulator.
2. TERMINAL
   You can spend very little or a lot on the terminal. A surplus machine can often be acquired at a hamfest for little cash investment. However, by the time you figure out how it works, fix it, and buy parts and manuals the total cost may not be so low. If you do, you'd better be prepared with tools, oil, and patience. Newer machines require less work, but also cost more. On a feature-for-feature basis, either the new DS2000 KSR or DS3100 ASR are more cost effective than other terminals presently available. Certainly a "solid" beginner's RTTY station would be the DS2000 KSR and ST-5000.

Some money-saving packaged "SYSTEMS" are offered for a limited time on the back page of this catalog.

HAL COMMUNICATIONS CORP.
Box 365
Urbana, Illinois 61801
217-367-7373

ST-6000 RTTY Demodulator

TOP OF THE LINE RTTY DEMODULATOR

Connect the ST-6000 between your transceiver and a HAL DS3100 ASR terminal and join in the fun of amateur RTTY. The ST-6000 provides outstanding recovery of HF RTTY signals, despite noise, interference, or weak signals. Deluxe features of the ST-6000 include a multi-pole active filter front-end, wide dynamic range limiter, either FM (hardlimiting) or AM reception, active filter discriminator and low-pass filters, and internal crystal-controlled AFSK tone keyer. The ATC (Automatic Threshold Control) and DTH (Decision Threshold Hysteresis) features minimize effects of selective fading and multi-path distortion of the RTTY signal. The ST-6000, available with either "Low" or "High" frequency tone sets, receives and transmits 170, 425, and 850 Hz shifts. Other features include internal loop supply, KOS (Keyboard Operated Switch) circuit, autostart, antispace, oscilloscope tuning indicator, and a rear panel with I/O connections for super-flexible interfacing to all data handling equipment. All in all, the ST-6000 is everything you could want in a demodulator.

SPECIFICATIONS

Electrical

Input Data and Rate: Serial Baudot or ASCII code, up to 110 baud.
Input Impedance: 600 ohms, balanced, transformer coupled.
Output Signals: 60 ma @ 175 VDC loop or low-level RS-232C.
Note: An auxiliary loop keyer is available to key a second loop with an external loop supply.
Miscellaneous Output:
Discriminator output to external scope, pre-autostart and post-autostart data, keyboard operated switch (KOS), printer motor AC power.
Autostart Response Time: Slow, 3.5 sec. Fast, 1.5 sec.
Printer motor Dropout Time: 20 sec. ± 10 sec.
Tuning Indicator: 1" scope.
Keyboard Operated Switch (KOS):
Transistor switch to actuate external circuits
Rated +25 VDC, 500 ma.

Frequency of "Low-tone" pairs.

Shift:	850 Hz	425 Hz	170 Hz
Mark:	1275 Hz	1275 Hz	1275 Hz
Space:	2125 Hz	1700 Hz	1445 Hz

Frequency of "High-tone" pairs.

Shift:	850 Hz	425 Hz	170 Hz
Mark:	2125 Hz	2125 Hz	2125 Hz
Space:	2975 Hz	2550 Hz	2295 Hz

CW ID shifts frequency of tone keyer down by 100 Hz.

Audio Tone Keyer

Input Signal: Dry contacts, EIA-RS-232C levels, or internal current loop, CW ID hand key.
Output Signal:
Levels: variable from −40 dbm to 0 dbm
Impedance: 600 ohm nominal, balanced.
Distortion: All harmonics below the 9th harmonic are greater than 40 db down.
Stability: Crystal controlled to ±.05%

Physical

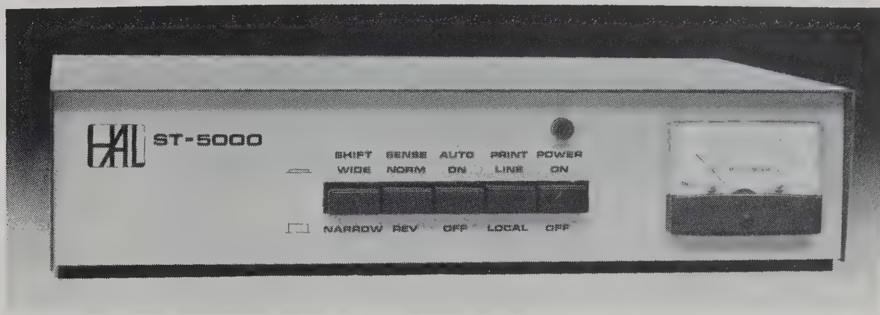
Cabinet Finish: Castle tan front and rear panel.
Textured chocolate brown top, bottom and side panels.
Cabinet Style: Table or 19" rack mount.
Size: Table: 3.50 H × 9D × 17 W (inches)
8,9 H × 22,8 D × 43,2 W (cm)
Rack: 3.50 H × 9 D × 19 W (inches)
8,9 H × 22,8 D × 43,3 W (cm)
Weight: 12.0 lbs (5,45 kg) net, 15.0 lbs. (6,82 kg) shipping.
Power: 105-125 VAC (210-250 VAC optional)
50-60 Hz, 20 Watts.

ST-6000 .... **$659.00**

(Specify table or rack and high- or low-tones when ordering.)

ST-5000 RTTY Demodulator

BIG RTTY PERFORMANCE FROM A SMALL DEMODULATOR



The HAL ST-5000 Demodulator provides excellent, reliable RTTY performance on both HF and VHF bands. Features such as a hard limiting front end, active discriminator, and active detector make this unit a big value. Wide and narrow shift (850 hz and 170 hz), normal or reverse sense, autostart, self-contained high voltage loop supply, and an audio tone keyer are standard. Connect the ST-5000 to your transceiver and your HAL keyboard and video display and take part in the growing world of coded communication.

SPECIFICATIONS

Input Data and Rate: Serial Baudot or ASCII code, up to 110 baud.
Input Signal: Audio tones in range 1200-3000 Hz.
Input Impedance: 600 ohms, unbalanced.
Output Signals: 60 ma, 175 VDC loop or low-level RS-232C.
Discriminator output to external scope, printer motor AC power, remote standby line.
Autostart Response Time: 2 to 4 seconds
Printer Motor Dropout Time: 20 to 40 seconds
Tuning Indicator: Front panel meter

Frequency of "High-tone" pairs

Shift:	850 Hz	170 Hz
Mark:	2125 Hz	2125 Hz
Space:	2975 Hz	2295 Hz

Frequency of "Low-tone" pairs

Shift:	850 Hz	170 Hz
Mark:	1275 Hz	1275 Hz
Space:	2125 Hz	1445 Hz

CW ID shifts frequency of tone keyer down by 100 Hz.

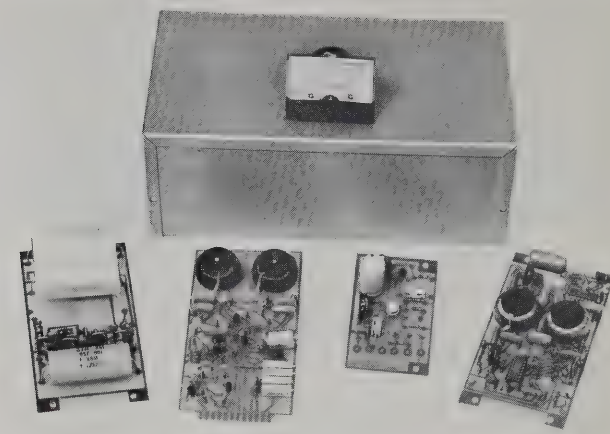
Tone Keyer Output (Phase coherent audio tones)
Levels: −32 dbm (20 mv nominal), variable from −40 dbm to 0 dbm by internal control.
Impedance: 600 ohm, unbalanced.
Distortion: All harmonics below the 9th harmonic are greater than 30 db down.
The tone keyer is equipped for the same tone pairs as the demodulator.

Cabinet Finish: Light beige bottom, front, and rear panel. Textured blue top and side panels.
Cabinet Style: Table mount.
Size: 2.75H × 8D × 12W (inches)
7,0H × 20,3D × 30,5W (cm)
Weight: 6.0 lbs. (2,73 kg) net, 9.0 lbs. (4,10 kg) shipping.
Power: 105-125 VAC (210-250 VAC optional) 50-60 Hz 20 watts.

ST-5000 .... **$239.00**

HAL PARTS KITS

ST-6K



ST-5K

For the experienced technician, HAL still offers the popular ST-6 and ST-5 demodulators in "kit" form. The units are offered in two attractive packages; the ST-6K package that includes the demodulator, cabinet, crystal tone keyer (former XTK-100), and discriminators for all three shifts (170-425-850 Hz). The ST-6 features input bandpass filters, wide-dynamic range limiter, balanced discriminator, active low-pass filter, ATC, autostart, and antispace. The tone keyer of the ST-6K is crystal controlled assuring accurate tone frequencies at all times. The ST-6 cabinet is pre-screened and drilled. The ST-5K package includes the demodulator, autostart (former ST-5AS), audio tone keyer (former AK-1), and Bud 2110 Minibox for use as a cabinet. The ST-5K package features a wide-dynamic range limiter stage, balanced discriminator, solid-state loop switch, autostart, tuning meter, and the popular AK-1 AFSK oscillator. An unscreened and undrilled Bud 2110 Minibox is provided for you to tailor to your requirements. The ST-5K represents the lowest cost RTTY demodulator available today.

SPECIFICATIONS

ST-6K

Input Level: 1.0 mV RMS minimum (FM)
50 mV RMS minimum (AM)
3.5 V RMS maximum
Input Impedance: 600 ohms, unbalanced
Input Frequencies: 2000-3000 Hz
Discriminator Frequencies:

Shift:	170	425	850 Hz
Mark:	2125	2125	2125 Hz
Space:	2295	2550	2975 Hz

Maximum Data Rate: 75 baud (100 wpm)
Autostart Response: "Slow"—3.5 sec.
"Fast"—1.5 sec.
Motor Control Time: Dropout in 30 ± 10 sec
Tuning Indicator: Front panel meter,
Provision for external scope
AFSK Tones: Same as discriminator (170 and 850 Hz Shift)
Output: Internal 60 ma/175 volt dc loop circuit and keyer transistor.
Low-level, RS-232 compatible data output.
Power: 105-125 or 210-250 vac, 50-60 Hz, 25 Watts
Cabinet: Two-tone gray in rack or table style
Size: 3.5H × 12D × 17W (19W for rack) inches
8.9H × 30.5D × 43.2W (48.3W for rack) cm
Weight: 14 lbs (6.4 kg) net; 16 lbs (7.3 kg) shipping

ST-6K Kit **$275.00**
(Specify table or rack cabinet)

ST-5K

Input Level: 1.0 mV minimum
3.5 V maximum
Input Impedance: 600 ohms, unbalanced
Input Frequencies: 2000-3000 Hz
Discriminator Frequencies:

Shift:	170	850 Hz
Mark:	2125	2125 Hz
Space:	2295	2975 Hz

Autostart Response: 2-4 sec.
Motor Dropout: 20-40 sec.
Tuning Indicator: Meter, Connector for External Scope
AFSK Tones: Same as Discriminator
Output: Internal 60 ma/175 vdc loop circuit and keyer transistor.
Low-level, RS-232 Compatible
Power: 120/240 vac, 50-60 Hz, 14 Watts
Cabinet: Bud 2110 Minibox (undrilled)
Gray Hammertone, unscreened
Size: 10 × 6 × 3.5 inches
25.4 × 15.2 × 8.9 cm
Weight: 7 lbs (3.2 kg) net; 8 lbs (3.6 kg) shipping

ST-5K Kit **$125.00**

NOTE: *HAL Parts Kits are intended for the experienced amateur technician. The kits do NOT include step-by-step instructions and the ST-5 Minibox is NOT screened OR drilled. The kits do, however, offer outstanding dollar savings as well as proven performance.*

ORDER BLANK

SOLD TO:	SHIP TO (If different)
NAME ____________	____________
ADDRESS ____________	____________
CITY ____________ STATE ______	____________
COUNTRY ____________ ZIP ______	____________
PHONE # ______ __ ______ __ ______	____________

QUAN.	EQUIPMENT	PRICE, EA.	TOTAL AMOUNT
	DS3100 ASR Terminal (Baudot, ASCII, and Morse)	$1995.00	
	Option: MPI-88T Printer with modification instructions	$ 750.00	
	Option: MPI-88T Printer with HAL modifications	$ 800.00	
	DS2000 KSR Terminal (Baudot and ASCII, TX Morse)	$ 499.00	
	Options: ESM-914 Display Monitor	$ 169.00	
	MR2000 Morse Receive Board	$ 159.00	
	ST6000 Demodulator Table Mount ☐ Rack Mount ☐		
	With Tuning Scope Low-Tone ☐ High-Tone ☐	$ 659.00	
	ST5000 Demodulator Low-Tone ☐ High-Tone ☐	$ 239.00	
	ST-6K Demodulator Parts Kit Table __ Rack __	$ 275.00	
	ST-5K Demodulator Parts Kit	$ 125.00	
	Custom Cable Set (specify HAL system, transceiver, and serial numbers	$ 50.00	
	Other:		
	Other:		
	Other:		
	Other:		
	Please specify: 110 VAC __ 220 VAC __ 50 Hz __ 60 Hz __		

Shipping Included in Price:

- UPS Regular Delivery ☐
- Parcel Post ☐

Extra Charge Shipping:

- UPS Blue Label ☐
- Air Mail ☐
- AIR Freight ☐
- COD UPS ☐ PP ☐
- Other ________ ☐

I read HAL ads in:

- QST ☐
- 73 ☐
- CQ ☐
- Ham Radio ☐
- H.R. Horizons ☐
- Other ☐

Total Amount of Goods:	$
System No. ____ Discount:	$
Sub-total:	$
5% Sales Tax (ILL Only):	$
Special Shipping:	$
Total This Order:	$

PAYMENT: (Make all checks to HAL COMMUNICATIONS CORP.)

☐ Personal Check No. ________ for $____________

☐ Money Order or Cashier's Check

NOTE: SYSTEM PRICES APPLY ONLY TO CASH WITH ORDER

☐ COD

☐ VISA/BAC No. ________ Eff. Dates ________ to ________

☐ M/C No. ________ Interbank ________ Eff. Dates ________ to ______

Mail Order to:
HAL COMMUNICATIONS CORP.
Box 365
Urbana, Illinois 61801

*A written copy of the applicable warranty is available at no charge upon request.
** COD Shipments Require Cash, Cashiers Check or money order. Personal checks are not accepted for COD's. COD charges are $1.25 per package (DS3100 ASR is shipped in two packages).

Prices and specifications subject to change without notice.

LIMITED TIME SYSTEM PRICES ON HAL EQUIPMENT

SYSTEM 1

DS3100 ASR	$1995.00
ST6000 Demodulator	$659.00
Regular HAL Price	$2654.00
SYSTEM 1 Price	**$2550.00**
	(Save $104.00)

SYSTEM 2

DS2000 KSR	$499.00
MR2000 Morse RCV Option	$159.00
ESM-914 Monitor	$169.00
ST6000 Demodulator	$659.00
Regular HAL Price	$1486.00
SYSTEM 2 Price	**$1435.00**
	(Save $51.00)

SYSTEM 3

DS2000 KSR	$499.00
MR2000 Morse RCV Option	$159.00
ESM-914 Monitor	$169.00
ST5000 Demodulator	$239.00
Regular HAL Price	$1066.00
SYSTEM 3 Price	**$1029.00**
	(Save $37.00)

RULES FOR SYSTEM ORDERS

1. The total System must be ordered at the same time.
2. System prices do not apply to orders placed prior to this announcement.
3. System prices apply only to the equipment combinations listed above.
4. System prices apply only to cash with order sales. Discounts do not apply to COD or charge card purchases.
5. This offer expires January 31, 1981, and will not apply to orders received after that date.
6. System prices apply to orders shipped to continental U.S.A. addresses only.
7. HAL Communications Corp. reserves the right to change the terms of this offer.

HAL COMMUNICATIONS CORP.
Box 365
Urbana, Illinois 61801
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FIRST CLASS MAIL

HERE IS YOUR NEW HAL COMMUNICATIONS CATALOG!

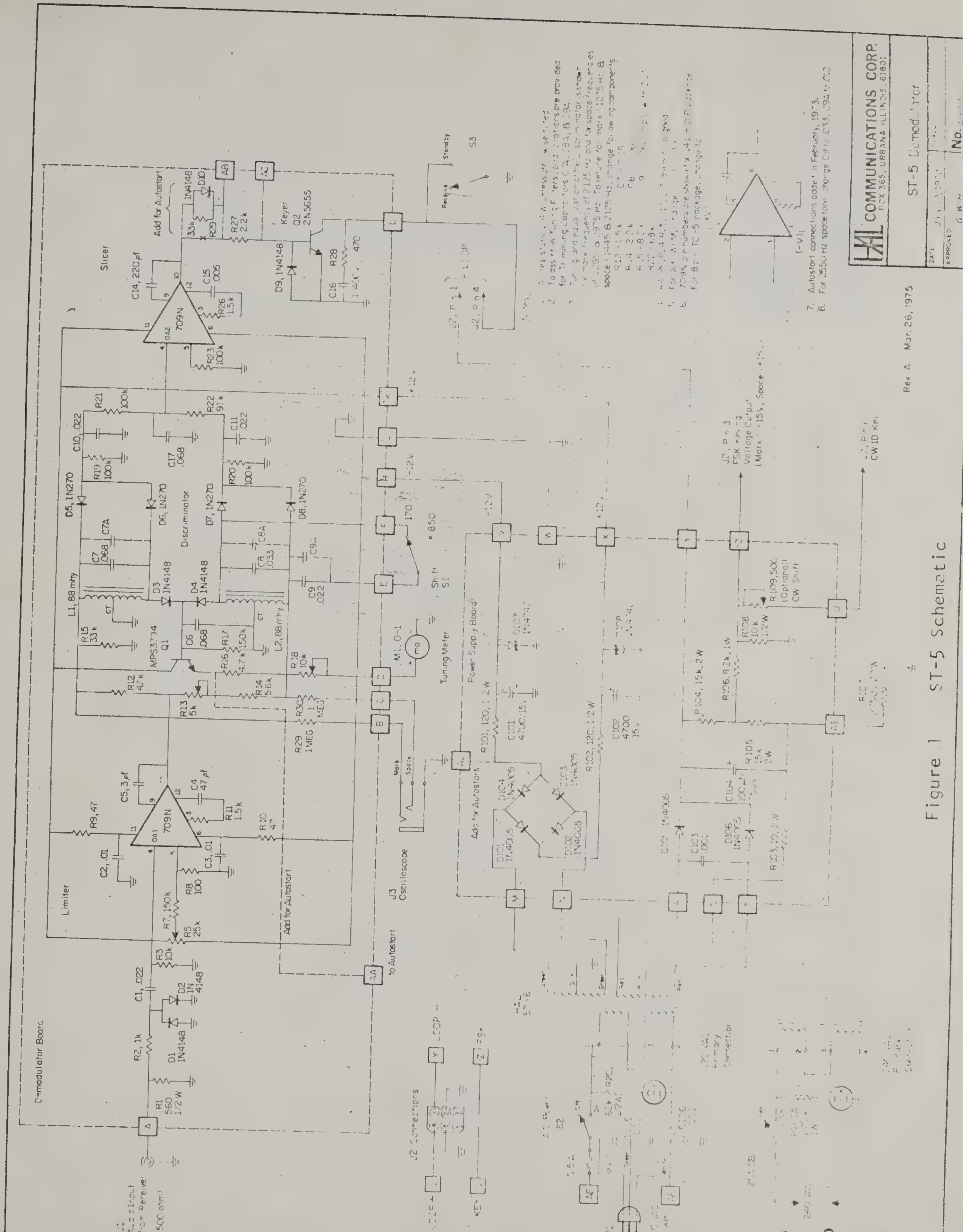


Figure 1 ST-5 Schematic

COPY by
1-15-76 WA6PHX
Marty Malone

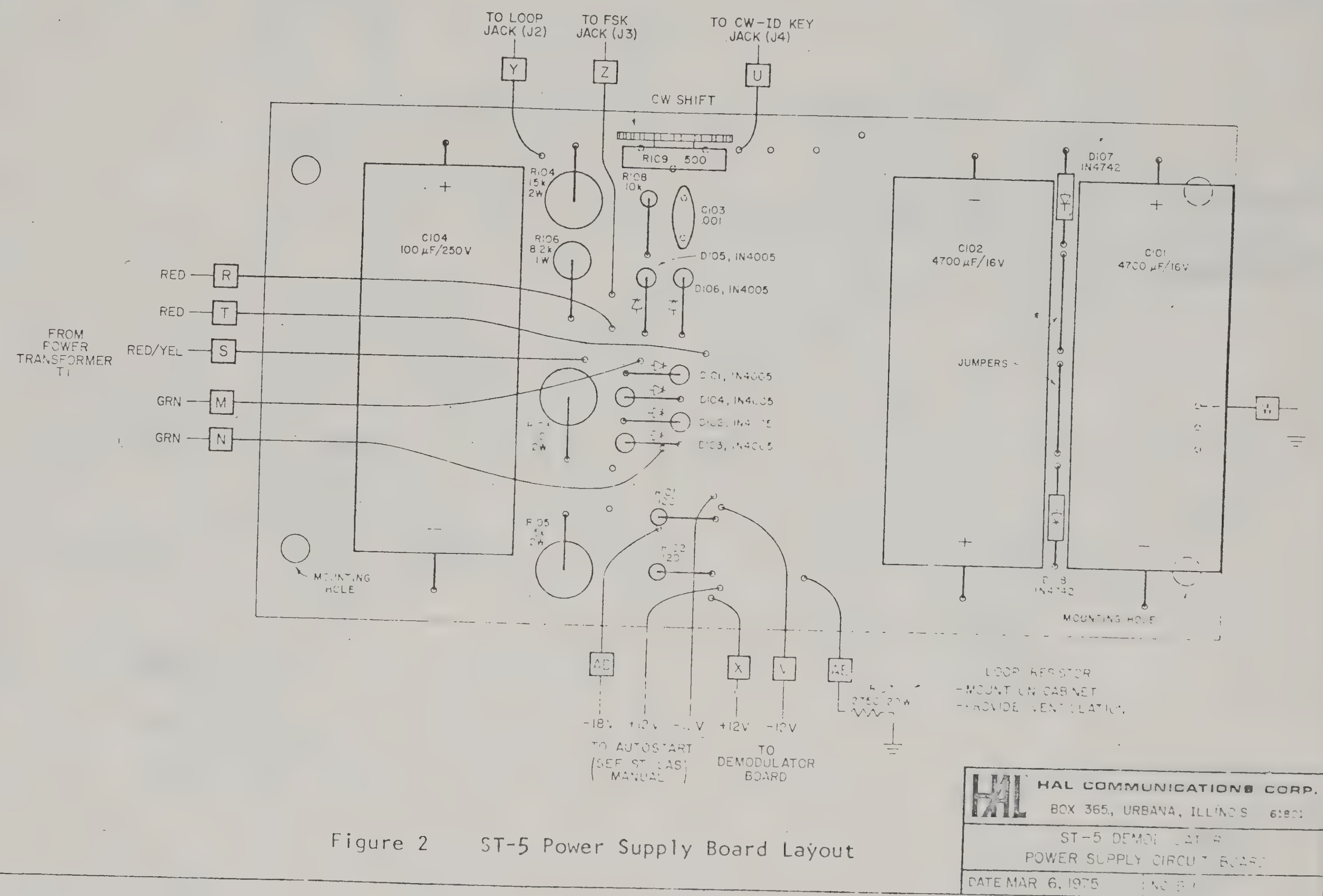
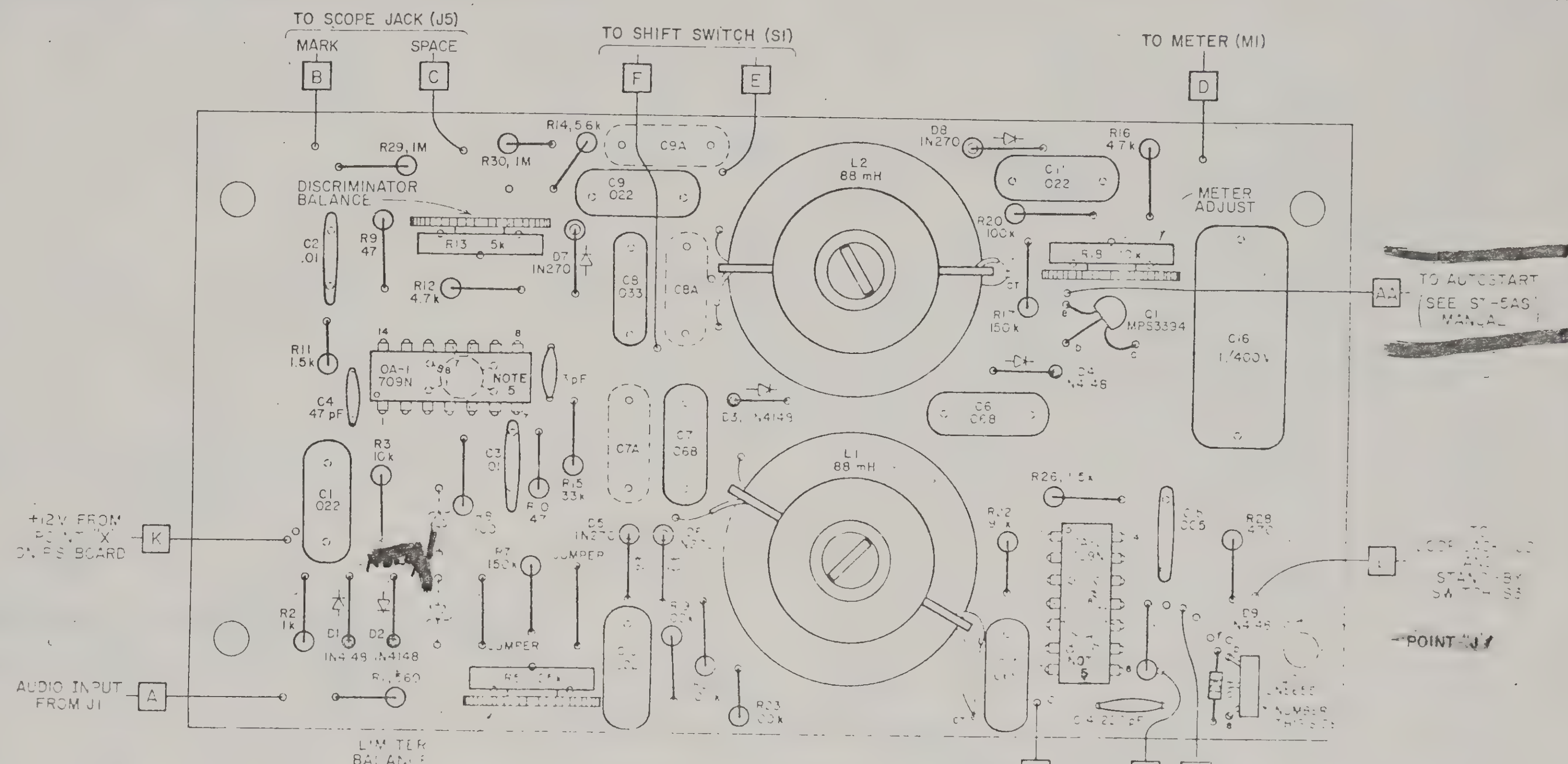


Figure 2 ST-5 Power Supply Board Layout



NOTE 1 THE GROUND RETURN (POINT) IS VIA MOUNTING TO CABINET

2 SEE ST-5AS MANUAL FOR MODIFICATIONS AND CONNECTIONS FOR AUTOSTART

3 SEE SCHEMATIC DIAGRAM FOR ALTERNATE PARTS VALUES FOR "LOW TONES"

4 THESE PADS ARE PROVIDED FOR ALTERNATE USE OF 3.6V ZENER DIODES FOR INPUT PROTECTION. OMIT DIODES D1 AND D2 IF USED

5 ADDITIONAL PADS ARE PROVIDED FOR ALTERNATE USAGE OF 709C IN 8-PIN, ROUND PACKAGE

HAL COMMUNICATIONS CORP.
BOX 365, URBANA, ILLINOIS 61801

ST-5 DEMODULATOR
DEMODULATOR CIRCUIT BOARD

DATE MAR

Figure 4 ST-5 Demodulator Board Layout

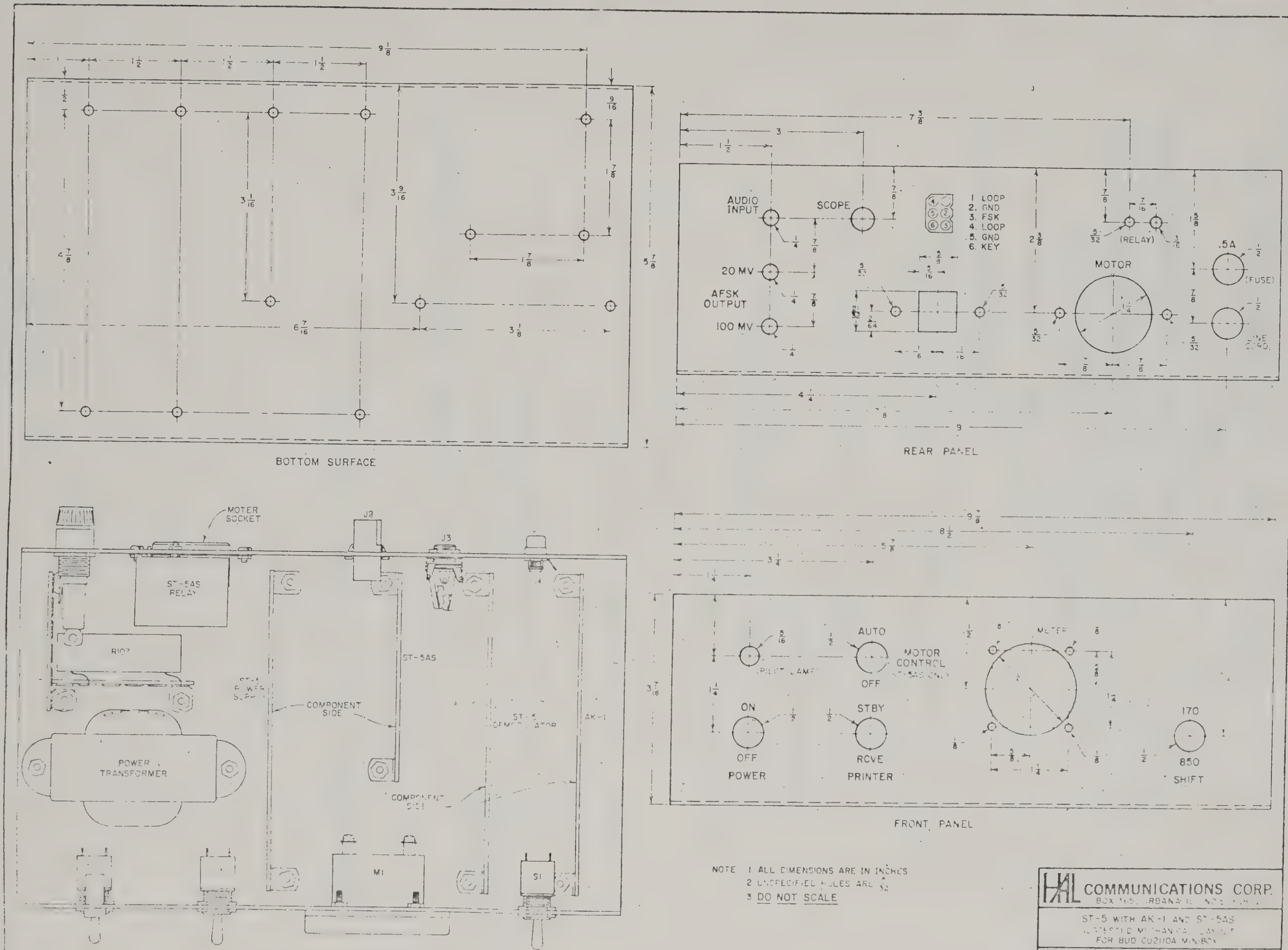


Figure 8 Mechanical Layout for CU2110A Box

2. SPECIFICATIONS

Input Frequency Range: 2125 - 2975 Hz (Standard)

1275 - 2125 Hz ("Low-Tones")

Input Impedance: 500 ohms, unbalanced

Limiter Performance: (at 2125 Hz)

Limiting Threshold - 1.0mV rms input

Maximum Signal Input - 3.5V rms

Discriminator Performance:

Mark Frequency, all shifts - 2125 Hz (Standard)

1275 Hz ("Low-Tones")

Space Frequency, 170 Hz shift - 2295 Hz (Standard)

1445 Hz ("Low-Tones")

Space Frequency, 850 Hz shift - 2975 Hz (Standard)

2125 Hz ("Low-Tones")

Discriminator Filter Bandwidth - 140 Hz

Minimum Usable Frequency Shift - (Standard Tones): 850 Hz - 50 Hz

170 Hz - 10 Hz

Maximum Usable Frequency Shift - (Standard Tones): 850 Hz - 1100 Hz

170 Hz - 350 Hz

Low-Pass Filter Cut-Off Frequency: 30 Hz (60 wpm, 45 baud)

50 Hz (100 wpm, 75 baud)

(Selectable by proper choice of component values)

St 5

Marty Malone WA6PHX

Outputs:

LOOP: An internal 175 volt, 60 ma loop power supply is keyed by the demodulator and connected to a panel connector to which the selector magnets at the teleprinter can be directly connected.

FSK: A bi-polar keying voltage output is supplied that is EIA (RS-232) compatible. This voltage is keyed by either the demodulator itself or by interruption of the loop circuit by external devices such as a keyboard or tape transmitter. This output can be used to key an FSK circuit for transmitting RTTY or to drive the HAL RVD-1005 Solid State Visual Display System, or the HAL AK-1 AFSK oscillator.

Nominal Voltages: Mark: $< -15V$

Space: $> +15V$

KEY: A telegraph key may be connected to the FSK system to provide narrow-shift CW-ID transmission. A separate potentiometer is provided to allow adjustment of the CW shift.

SCOPE: AC voltages proportional to the signals in the discriminator filters are provided to allow use of an oscilloscope to aid in tuning the receiver. Since a tuning meter is provided with the ST-5, use of the "Scope" output is optional. Approximately 4V peak-to-peak (at the center frequency of each discriminator filter) is furnished with an internal impedance of 1 megohm.

Miscellaneous Data:

Fuse Protection: 0.5A fuse in AC power line

Power Requirement: 120/240 VAC, 50-60 Hz, $\pm$ 10%

(Power cords are furnished for U.S. standard three-wire 120 VAC connections; other connectors must be user-supplied if required.)

Power Consumption: 14 watts maximum

Shipping Weight: 5 lbs.

5. TEST AND ALIGNMENT

After the ST-5 has been completely assembled, double-check all wiring to make sure there are no errors. Particularly make sure that the ac power, loop supply, and low voltage supplies are correctly connected.

5.1 Preliminary Power Supply Tests

CAUTION: IN THE FOLLOWING STEPS, POTENTIALLY LETHAL VOLTAGES ARE EXPOSED IN THE CABINET WIRING. BE VERY CAREFUL WHEN MAKING MEASUREMENTS TO AVOID TOUCHING EXPOSED TERMINALS.

Put a ½ ampere fuse in the fuse holder and plug the line cord into a grounded three-prong ac power outlet (or suitable power source if using 220 VAC.)

DO NOT DEFEAT THE GROUNDING PLUG FEATURE. TO DO SO COULD PRESENT A SHOCK HAZARD, LEAD TO RF INTERFERENCE PROBLEMS, AND WILL VOID ANY WARRANTY BY HAL COMMUNICATIONS.

Turn the AC Power switch on. The pilot lamp should light. Make the following voltage measurements in the ST-5 using a 20,000 ohms-per-volt VOM:

1. Measure 115 VAC between terminals 1 and 2 and between terminals 3 and 4 of the power transformers. These measurements will be the same for either 115 or 230 VAC power input connections.
2. At point "K" on the demodulator board, measure +12 VDC, ± 1.2 volts.
3. At point "H" on the demodulator board, measure -12 VDC, ± 1.2 volts.
4. With switch S3 in "Standby" position and a jumper between pins 4 and 1 of J2, measure approximately -155 VDC (± 10%) across the loop resistor, R107.
5. Remove the jumper from pins 4 and 1 of J2 and measure approximately +170 VDC (± 10%) at point "Y" on the power supply board.
6. At point "AD" on the power supply board, measure approximately -20 VDC (± 15%).
7. Turn the power switch off.

If the previous voltage measurements check, proceed to the next step. If they do not check-out, a wiring error has been made and should be corrected before continuing.

5.2 Alignment of the ST-5

Short the audio input to the ST-5 (jack J1), turn-on the power, and measure the DC voltage at pin 10 of IC OA-1. Adjust potentiometer R5 to obtain as close as possible to zero volts at pin 10. Since OA-1 is connected for very high gain, it may not be possible to adjust R5 for exactly zero volts.

Remove the short from J1 and connect an audio oscillator to J1. The oscillator should be capable of approximately 1.0 volt rms output in the 1.0 to 3.0 kHz frequency range. Adjust the oscillator frequency and note the readings on the tuning meter. With the Shift Switch (S1) set for 850 Hz, the meter reading should peak at approximately 2.1 and 3.0 kHz. Set the oscillator frequency to the meter peak near 2.1 kHz. Adjust potentiometer R18 to give a meter reading of 0.7 ma. Change the oscillator frequency to get a meter peak reading near 3 kHz. Adjust potentiometer R13 to again get a meter reading of 0.7 ma.

Connect a 0 to 100 ma meter (or VOM on the 100 ma scale) between pins 4 and 1 of a 6 pin connector with the positive lead to pin 1 and the negative lead to pin 4. Turn the ST-5 off and wait 30 seconds to assure that the filter capacitors have discharged. Insert the plug into J2. Turn the ST-5 back on. With the signal generator frequency set below approximately 2400 Hz, the meter should indicate a loop current of 60 $\pm$ 10 ma. When the generator frequency is above 2600 Hz, the loop current should be zero.

The discriminator tuned circuits can now be adjusted. Connect a frequency counter or other accurate frequency measuring device to the audio oscillator. Since the discriminator tuned circuits have a relatively wide bandwidth, measurement of the frequency corresponding to a peak tuning meter reading is difficult. A much more accurate technique is to measure frequencies on either side of the peak and calculate the mid-point. For example, to measure the center frequency of the mark circuit, first make sure that the peak meter reading is approximately 0.7 ma. Next, adjust the oscillator frequency up in frequency until a meter reading of 0.6 ma is obtained. Record this frequency. Adjust the oscillator down in frequency, past the peak, until the lower frequency corresponding to a meter reading of 0.6 ma is obtained. Record this frequency. The center frequency can now be determined by adding the two frequencies and dividing by two. Use this technique to measure all center frequencies.

With the shift switch in the 850 Hz position (switch S1), measure the mark frequency. The measured frequency will generally be below the desired 2125 Hz mark frequency. If so, adjust the tuning by removing turns from L1 at the approximate rate of 3 Hz per turn removed. DO NOT attempt to make large frequency adjustments in one step. Rather, remove almost enough turns and then remeasure the center frequency; it is far easier to remove additional turns than to put some back on the toroid. If more than 10 turns must be removed from a toroid, remove an equal amount from each half to maintain the detector balance. If the original center frequency is higher than 2125 Hz, lower the resonant frequency by adding capacitance at location

5

C7A at the rate of 2 Hz per 100 pf added. After the mark circuit has been set to a center frequency of 2125 Hz, recheck the adjustment of R18 and re-adjust if necessary.

Next, change the signal generator frequency to give a peak meter indication near 3 kHz. Readjust R13, if necessary, to give a meter reading of 0.7 ma. As before, compute the space circuit center frequency by measuring the frequencies corresponding to a 0.6 ma meter reading. This circuit will generally be tuned higher than the desired 2975 Hz center frequency. If so, lower the resonant frequency by adding capacitance at location C8A at the rate of 5 Hz per 100 pf added. If the frequency must be increased, remove turns from L2 at the rate of 5 Hz per turn removed, again being careful to avoid removing too many turns. When the center frequency has been adjusted, the 850 Hz shift mode is now aligned.

To align the 170 Hz shift mode, switch S1 to 170 Hz and tune the oscillator to the mark frequency, 2125 Hz. Since the same tuned circuit is used for both 170 and 850 Hz shift, the mark circuit should already be aligned. Note the tuning meter reading at the peak for the mark frequency. It may or may not be equal to 0.7. If not, adjust R18 to give a 0.7 ma meter indication. Next, locate the center frequency of the space circuit and adjust R13 for a meter reading of 0.7 ma. As before, compute the center frequency and adjust ONLY the capacitor to get a center frequency of 2295 Hz. Additional capacitors, if needed, can be placed at location C9A. If it is necessary to adjust L2, the alignment of the 850 Hz space circuit must be repeated since this toroid is common to both 170 and 850 Hz space filters. Adjustment factors are the same as for 2125 Hz, 2 Hz per 100 pf or 3 Hz per turn.

Note: Because the same tuned circuit is used for both the 170 Hz and 850 Hz space filters, potentiometers R13 and R18 can only be set exactly for one or the other shifts. It is suggested that they be adjusted for the more critical operations at 170 Hz shift as a final alignment step. As discussed before, set R18 first for 0.7 ma meter reading at 2125 Hz (mark) and then R13 for 0.7 ma at 2295 Hz (space).

Alternate Low-tone Alignment

Measure frequencies and adjust as described above, except the frequencies should be 1275 Hz for mark and 1445 Hz for 170 Hz shift space and 2125 Hz for 850 Hz space. Be sure to use the alternate values for C7, C8, and C9 as well as for R12, R14, R15, and R22 described in note 3 in Figure 1.

The alignment and adjustment of the ST-5 is now complete.

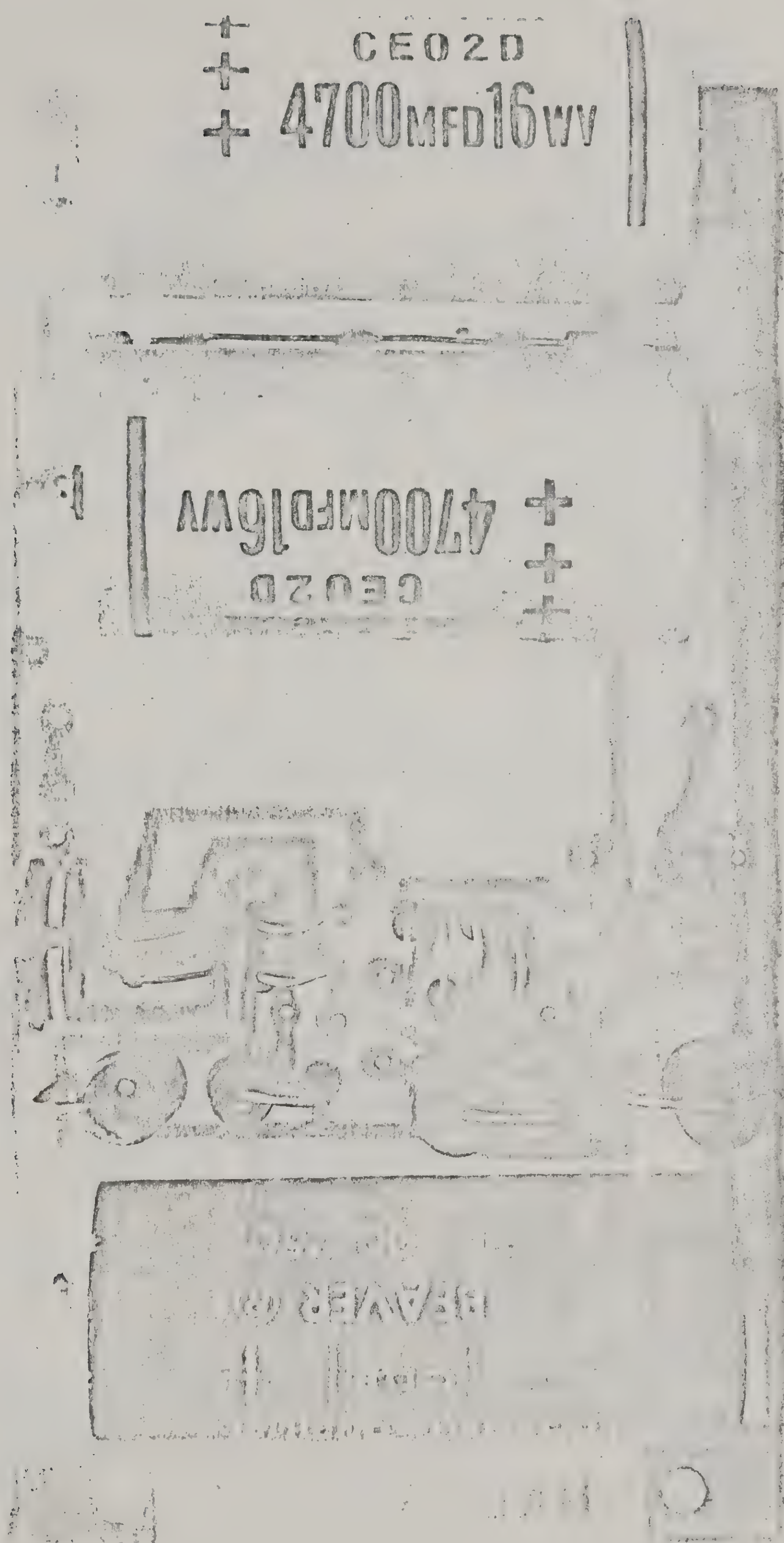


Figure 3 ST-5 Power Supply Board

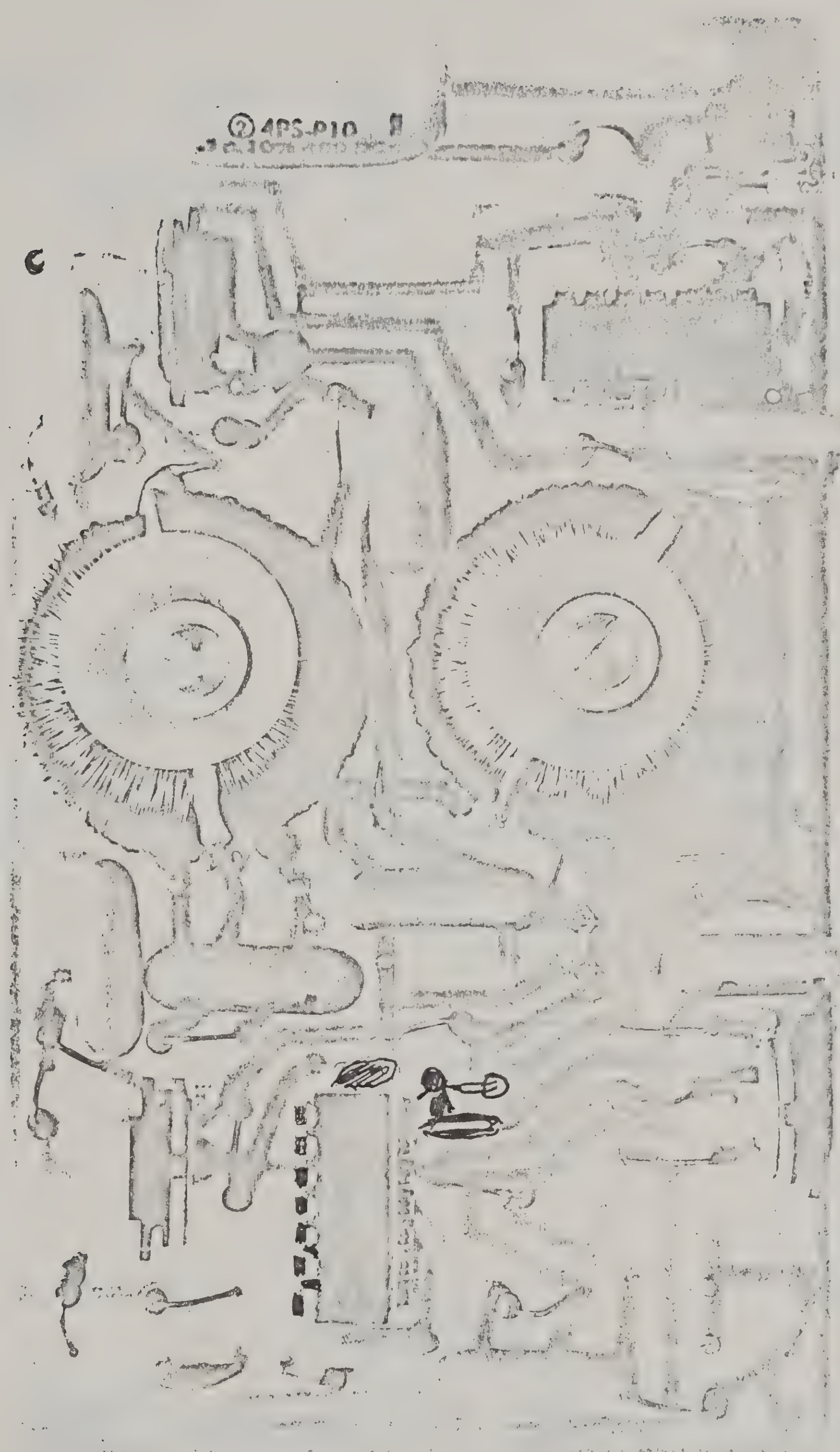


Figure 5   ST-5 Demodulator Board

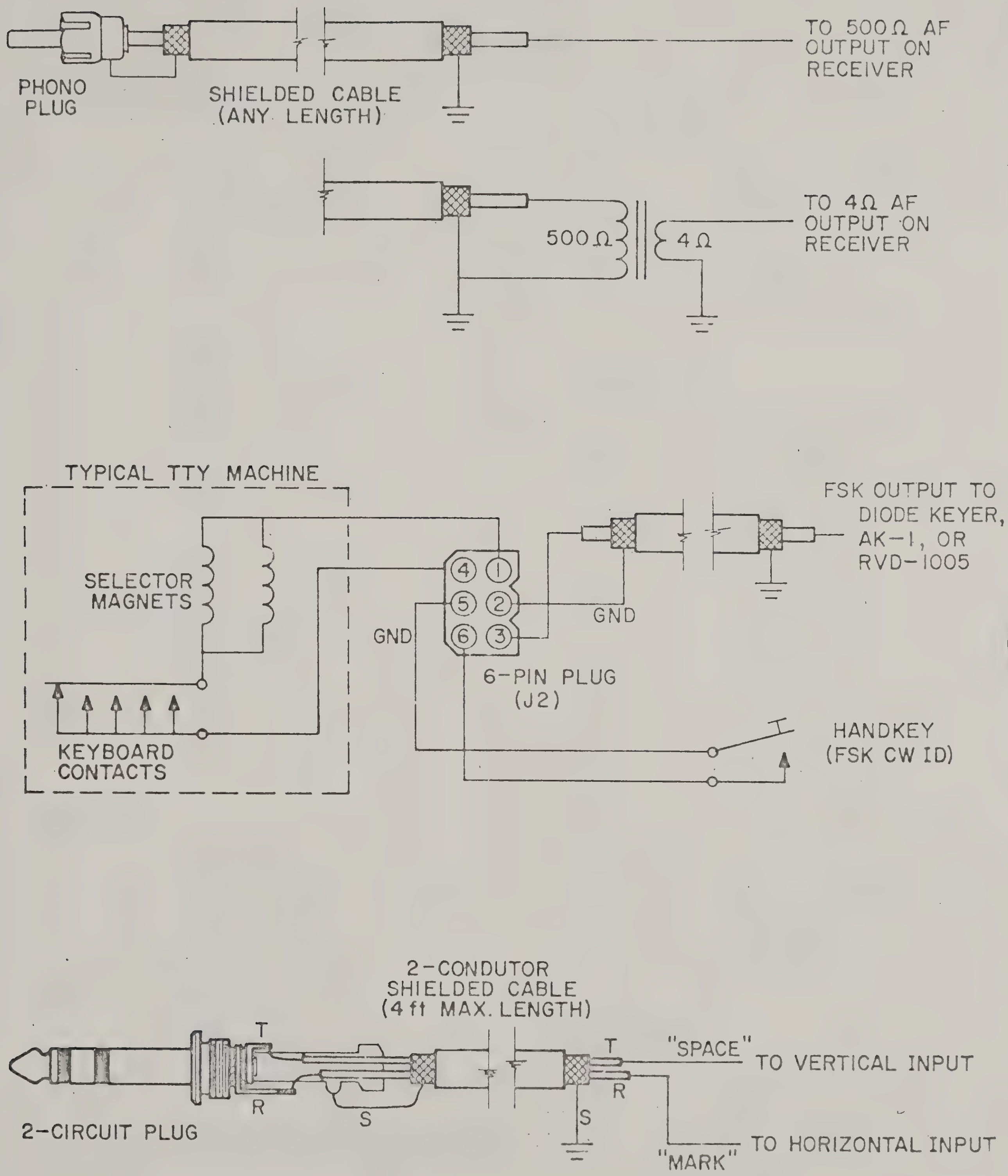


Figure 9 . Plug Connections

PARTS LIST ST-5

Resistors (1/4 watt unless noted)

( )	2	47
( )	1	100
( )	2	120 (1/2 w)
( )	1	470
( )	1	560
( )	1	1K
( )	2	1.5K
( )	1	2.2K
( )	2	4.7K
( )	1	5.6K
( )	2	10K
( )	1	33K
( )	1	82K (1/2 w)
( )	1	91K
( )	4	100K
( )	2	150K
( )	2	1Meg
( )	1	8.2K (1 watt)
( )	1	10 ohms (2 watt)
( )	2	15K (2 watt)
( )	1	500 ohm trimpot
( )	1	5K trimpot
( )	1	10K trimpot
( )	1	25K trimpot
( )	1	2750 ohm (20 watt)

Capacitors

( )	1	3pf disc
( )	1	47 pf disc
( )	1	220 pf disc
( )	3	.001 uf disc
( )	1	.005 uf disc
( )	2	.01 uf disc
( )	4	.022 O.D.
( )	1	.033 O.D.
( )	3	.068 O.D.
( )	1	.1 uf 400 VDC O.D.
( )	1	100 uf 250 VDC electrolytic
( )	2	4700 uf 15 VDC electrolytic

Semiconductors

( )	2	709
( )	1	2N5655 or MJE340
( )	1	MPS3394
( )	4	1N270
( )	5	1N4148
( )	6	1N4005
( )	2	1N4742

Miscellaneous

( )	2	88 mhy toroid
( )	2	SPST toggle
( )	1	DPDT toggle
( )	1	500 ma (1/2A) fuse
( )	1	strain relief
( )	1	phono jack
( )	1	phono plug
( )	1	6 pin socket
( )	2	6 pin plugs
( )	6	Female pins
( )	12	Male pins
( )	1	stereo phone jack 1/4"
( )	1	stereo phone plug
( )	2	Toroid retainers
( )	2	6-lug terminal strip
( )	4	angle brackets
( )	2	6 - 32 x 3/4" screw
( )	16	6 - 32 x 3/8" screw
( )	16	6 - 32 locknuts
( )	4	7 pin IC socket strips
( )	1	neon lamp assembly
( )	1	fuseholder
( )	2	#6 ground lugs

ST-5 Boxing

( )	1	Board Set
( )	1	Meter
( )	1	ST-6 transformer
( )	1	Line cord
( )	1	Manual
( )	25 ft.	Hook-up wire

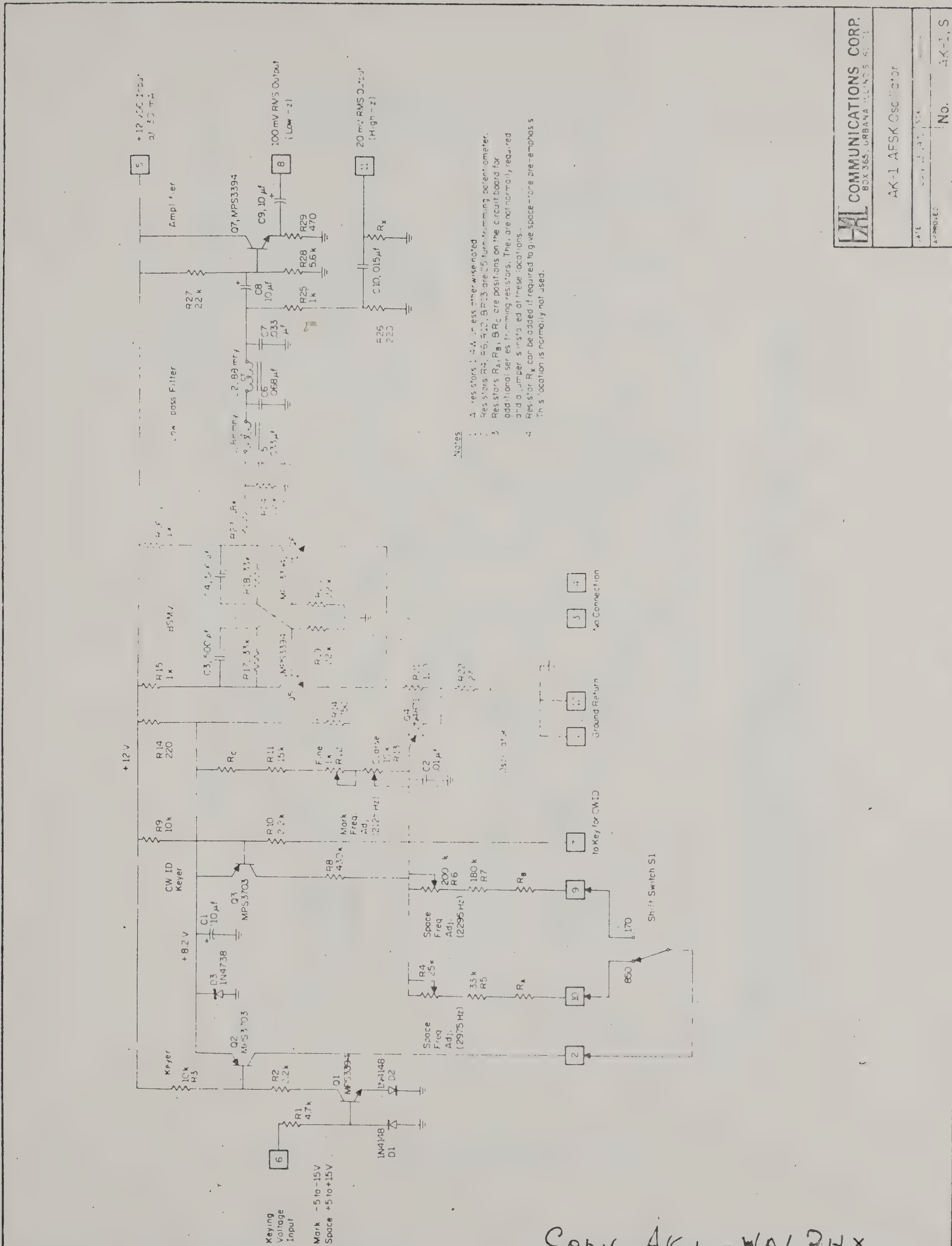
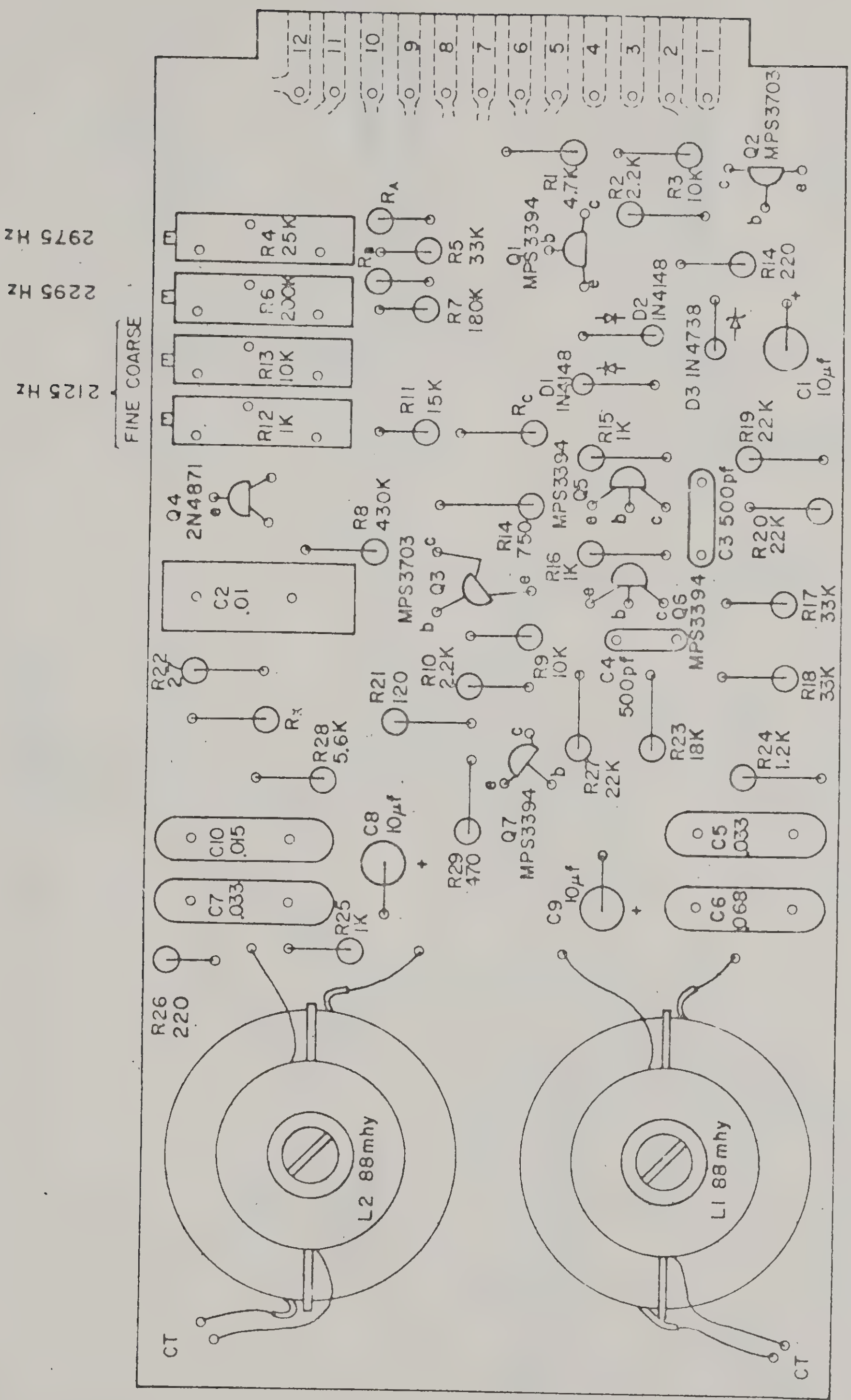


Figure 1. AK-1 Schematic Diagram

Copy AK1 - WA6PHX
marty malone



NOTES:

1. REFER TO SCHEMATIC FOR EDGE-CONNECTOR PIN CONNECTIONS.
2. RESISTORS R_A, R_B, & R_C ARE LOCATIONS FOR TRIMMING RESISTORS IF NEEDED. NORMALLY, THESE RESISTORS ARE NOT REQUIRED AND A JUMPER IS PLACED IN THEIR LOCATION.
3. RESISTOR R_X CAN BE USED TO PROVIDE A SMALL AMOUNT OF SPACE-TONE PRE-EMPHASIS. CONSULT THE MANUAL FOR SELECTION TECHNIQUES.

Figure 2. AK-1 Circuit Board Layout

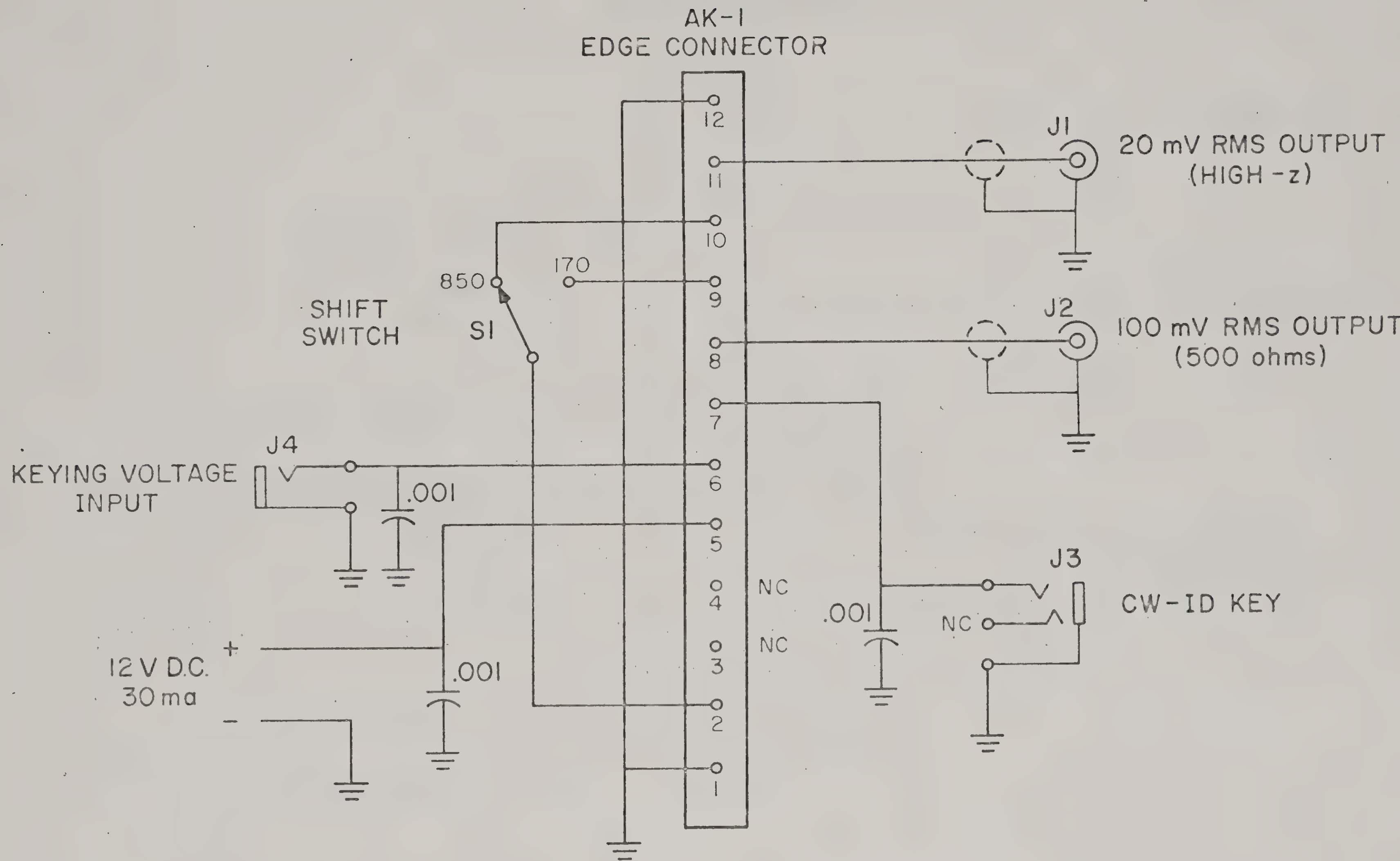


Figure 4 Typical Connections to AK-1

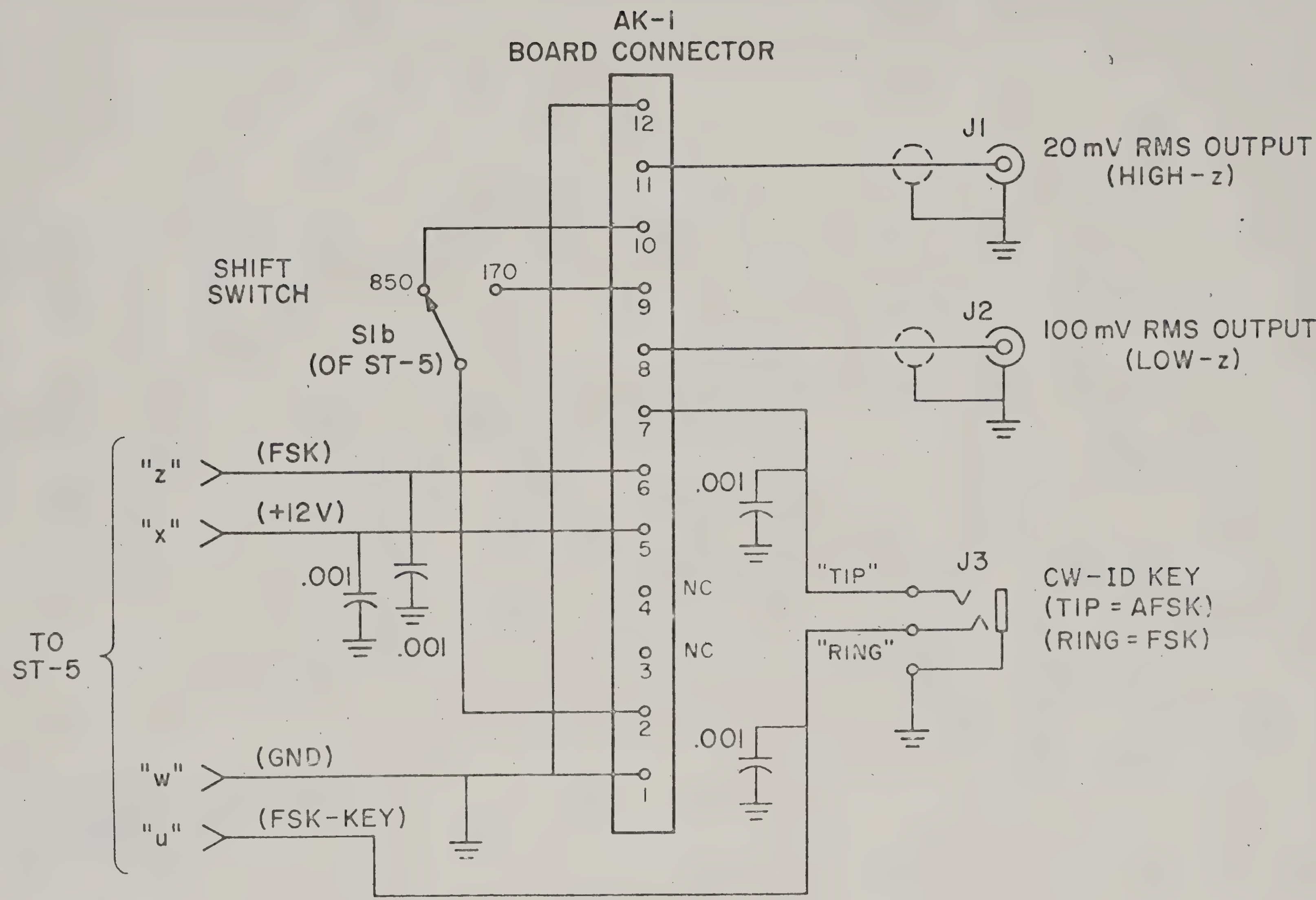


Figure 8 AK-I Connections to ST-5

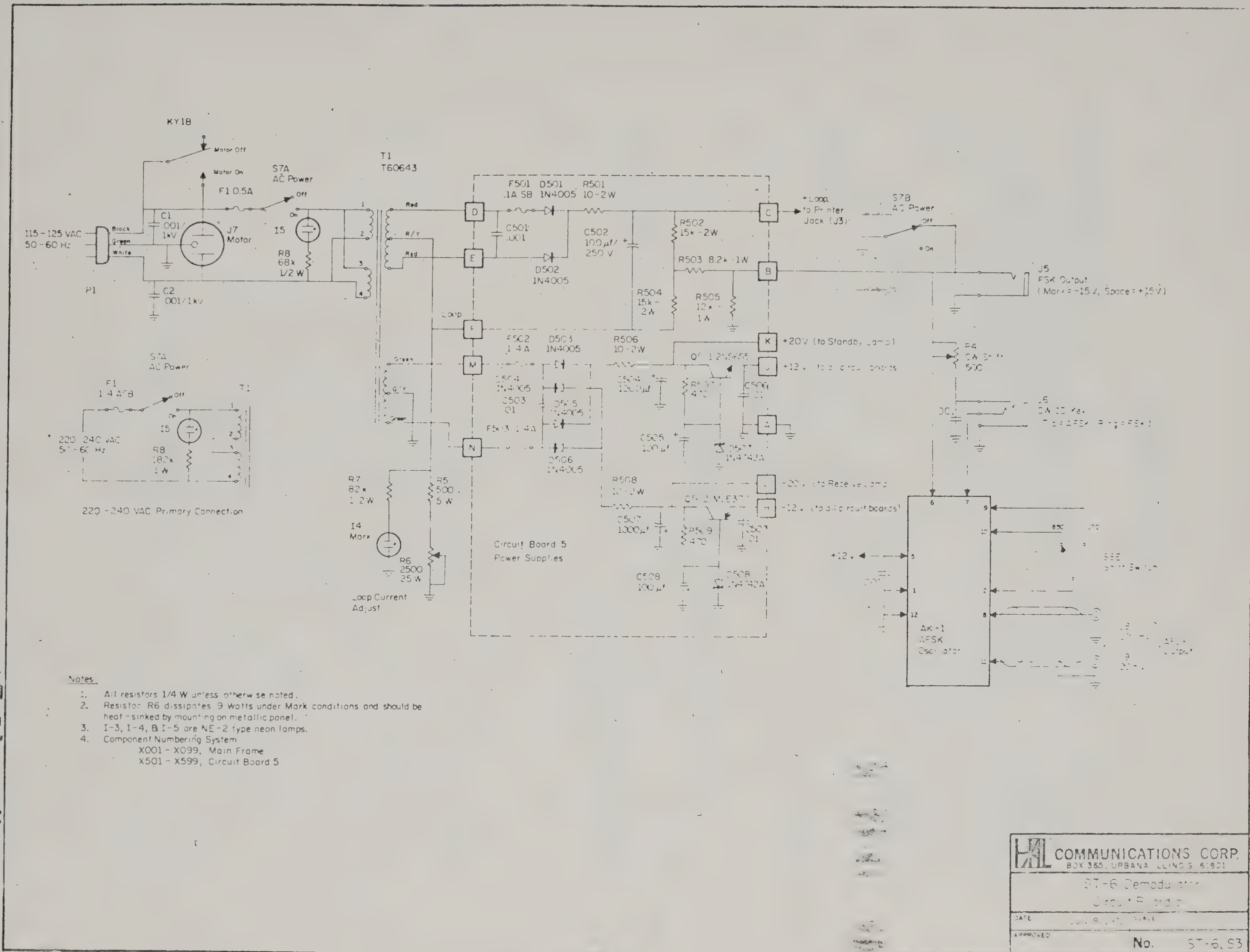


Figure 9. AK-1 Connections to ST-6

Copy 1-15-75 - WA6PHX

2. SPECIFICATIONS

Output Frequencies:

Mark (170 and 850 Hz shifts)	2125 Hz
Space (170 Hz shift)	2295 Hz
Space (850 Hz shift)	2975 Hz
CW ID (key down)	2225 Hz

Output Amplitude:

High-Level Output	100 mV rms
Low-Level Output	20 mV rms

Frequency Stability (after 15 minute warm-up) . . . . ± 5 Hz (all tones)

Standard Frequency Shifts available . . . . 170 and 850 Hz

Input Keying Voltage Requirements:

Mark	less than 0 volts, greater than -20 volts
Space	greater than +5 volts, less than +20 volts

Power Requirements . . . . +12 V dc @ 30ma

Size . . . . 2 7/8" X 5 3/4" circuit board (7.0 X 14.6 cm)

3. OPERATION OF THE AK-1

The circuit of the AK-1 AFSK Oscillator (see Figure 1, page 16) is made up of five basic sections: oscillator, keyer, divider, filter, and output amplifier. The signal is generated in a unijunction relaxation oscillator (Q4) at twice the desired output frequency. The exact mark frequency of oscillation is determined by the combination of C2 and R11, R12, and R13 (also Rc, if used). The frequency of oscillation is changed from mark to space condition by paralleling the R11, R12, R13 chain with either R6 and R7 (170 shift) or R4 and R6 (850 shift) series resistor chains. Therefore, shifting from mark to space frequencies is accomplished by changing the charging time-constant of capacitor C2, a procedure that generates no abrupt phase discontinuities in the oscillator waveform. This is a particularly important feature of the AK-1 when it is to be used in a SSB-type of transmitter system. For instance, oscillator circuits that use tuned-circuits will generate spurious signals due to phase discontinuities when shifting from mark to space. These spurious signals rarely cause problems in VHF-type AM or FM applications but will cause radiation of illegal signals when used with a SSB-type of transmitter. The AK-1 will not produce this type of spurious signal.

Changing the frequency from mark to space is accomplished electronically by keyer stages Q1 and Q2. Keying voltages are presented to pin 6 of the edge connector with the convention that for mark condition the voltage should be zero or less (preferably between -5 and -15 volts) and greater than +5 for space condition. Therefore, during mark, Q1 is "off" as is Q2 and the effective charging resistor for C2 is only the R11, R12, and R13 series chain. During space, both Q1 and Q2 are turned "on", paralleling either R4 and R5 or R6 and R7 (depending upon which is selected by S1) with the R11, etc. chain.

A separate keyer transistor, Q3, is provided for CW identification. When pin 7 of the edge connector is grounded, Q3 is biased "on" and R8 is placed in parallel with the R11, etc. chain, increasing the frequency by approximately 100 Hz. Note that this stage can be activated at any time and it is therefore important that the key (or its shorting-bar) not be closed during RTTY transmission. R8 has been chosen to give approximately 100 Hz shift from the mark tone, but the exact amount of CW ID shift can be adjusted by changing the value of this resistor.

It is important to note that both space tone and CW ID frequencies are determined by their respective resistor chains in parallel with the mark resistor chain. Therefore, it is necessary that the mark frequency be adjusted first since any change in this resistor chain will affect all other tones. To allow compensation for the wide range of possible variation of the unijunction oscillator transistor, Q4, and timing capacitor C2, both a fine and coarse adjustment are provided for the mark frequency. The ranges of all potentiometers have been chosen so that it should always be possible to adjust to the correct frequencies without changing fixed resistors if the unit is constructed correctly.

The output of the oscillator across resistor R22 is a 2 volt spike at twice the desired output frequency. The divider stage (BSMV), Q5-Q6, is triggered by these pulses. The output of the divider (measured at the collector of Q6) should be a square-wave of approximately 10 volts peak-to-peak amplitude and with a frequency equal to the desired output frequency (2125 Hz for mark with key-up).

The low-pass filter removes all but the fundamental component of the square-wave, resulting in a sinusoidal output waveform. R24 is the input terminating resistor for the filter and R23 is a divider to reduce the voltage output and provide some isolation between the divider and filter. If desired, the output of the AK-1 can be increased somewhat by reducing the value of R23, but care should be taken to maintain the same parallel equivalent of R23 and R24 to keep the proper filter termination impedance. Since it is only necessary that the filter provide rejection of the harmonics of the divider output (odd-order harmonics for the square-wave), the filter does not require critical timing and can be assembled directly. If problems are suspected with the filter circuit, the pass-band can be checked by removing the end of resistor R23 from the collector of Q6 and substituting an audio oscillator, observing the output across C7. The filter should be "flat" (within 1.0 dB) up to 3000 Hz and should be of the order of 13 dB down at 4250 Hz (2 X 2125) and 31 dB down at 6375 Hz (3 X 2125). This check is not normally required and should only be necessary if problems occur.

Two outputs are provided from the AK-1: an attenuated, high-impedance output of 20 mV rms for typical connection to the high-impedance microphone input on a transmitter, and a 500 ohm, 100 mV rms output that can be used for carbon-microphone inputs, to drive counters, and other high-level applications. Transistor Q7 is used as an emitter-follower isolation amplifier to drive the 100 mV output. When connecting to the 100 mV output, it should be remembered that the coupling capacitor, C9, is electrolytic and leakage inherent in any electrolytic will produce a dc voltage if a very high impedance device is connected to this output. This is particularly true of some counter input circuits and, on counters without a blocking input capacitor, can cause false counting. The cure is to terminate the output in 1K to 10K ohms. Another precaution for use of the 100 mV output is to maintain fairly low shunt capacitance across the output. Under some conditions, transistor Q7 will oscillate in the 5 to 10 MHz range if the 100 mV output is capacitively loaded. The cure is to reduce the capacitance of the load, or use ferrite beads on the leads of Q7. Use of resistor Rx to provide space-tone pre-emphasis is discussed in detail in the applications section of this manual.

Power required by the AK-1 is connected to pins 5 (+12V @ 30 ma) and 1 and 12 (ground return). An additional zener regulator, D3, provides +8.2 volts regulated to the oscillator circuit, but regulation of the +12 volt input is also highly recommended.

6. TEST AND ALIGNMENT

Refer to the schematic diagram, Figure 1, and the circuit board layout, Figure 2, to locate the test points mentioned in the following procedure.

After the AK-1 circuit board and related connectors and power supply have been wired, apply power to the oscillator and check for the presence of +12 volts dc at pin 5 of the edge connector and for +8.2 V dc at the emitters of Q_2 and Q_3. The total current drain from the +12 volt power supply should be of the order of 30 ma $\pm$ 5 ma. If the voltages are not correct or if the current consumption is wrong, a mistake in wiring has been made and should be located and corrected before proceeding. If an oscilloscope is available, proper operation of the oscillator and bistable multivibrator (BSMV) can be checked. The waveform across the 0.01 μfd polystyrene timing capacitor should be a saw-tooth of approximately two-times the desired output frequency and the waveforms at the collectors of either Q_5 or Q_6 should be square waves of the same frequency as the output. The waveform at the base and emitter of Q_7 should be a sine-wave at the output frequency.

If an oscilloscope is not available, the 100 mV output of the AK-1 can be coupled to a RTTY demodulator and the tones adjusted to the frequencies of the demodulator. Generally, there should be little trouble with the AK-1, experience has shown that 99% of problems with the AK-1 can be traced to wiring errors.

After it is determined that the AK-1 is functioning correctly, the frequencies of the tones should be checked with a frequency counter. The counter should be connected to the 100 mV output. Note that some counters (such as the Heath IB-101) have a very high input impedance and no blocking capacitors. In this case, the very small, but finite, leakage in electrolytic capacitor C_9 can place a dc potential at the counter input and cause no indication or faulty indication. It is therefore recommended that the 100 mV output be terminated in 1000 ohms when aligned in this manner. Always adjust the AK-1 in the mark condition first and then adjust the two space tones. Therefore, set the input keying signal for marking condition and adjust R_{12} and R_{13} for an output of 2125 Hz. Note that R_{13} is a coarse adjustment and R_{12} is a fine adjustment for the mark tone. The mark tone should be 2125 Hz for either shift.

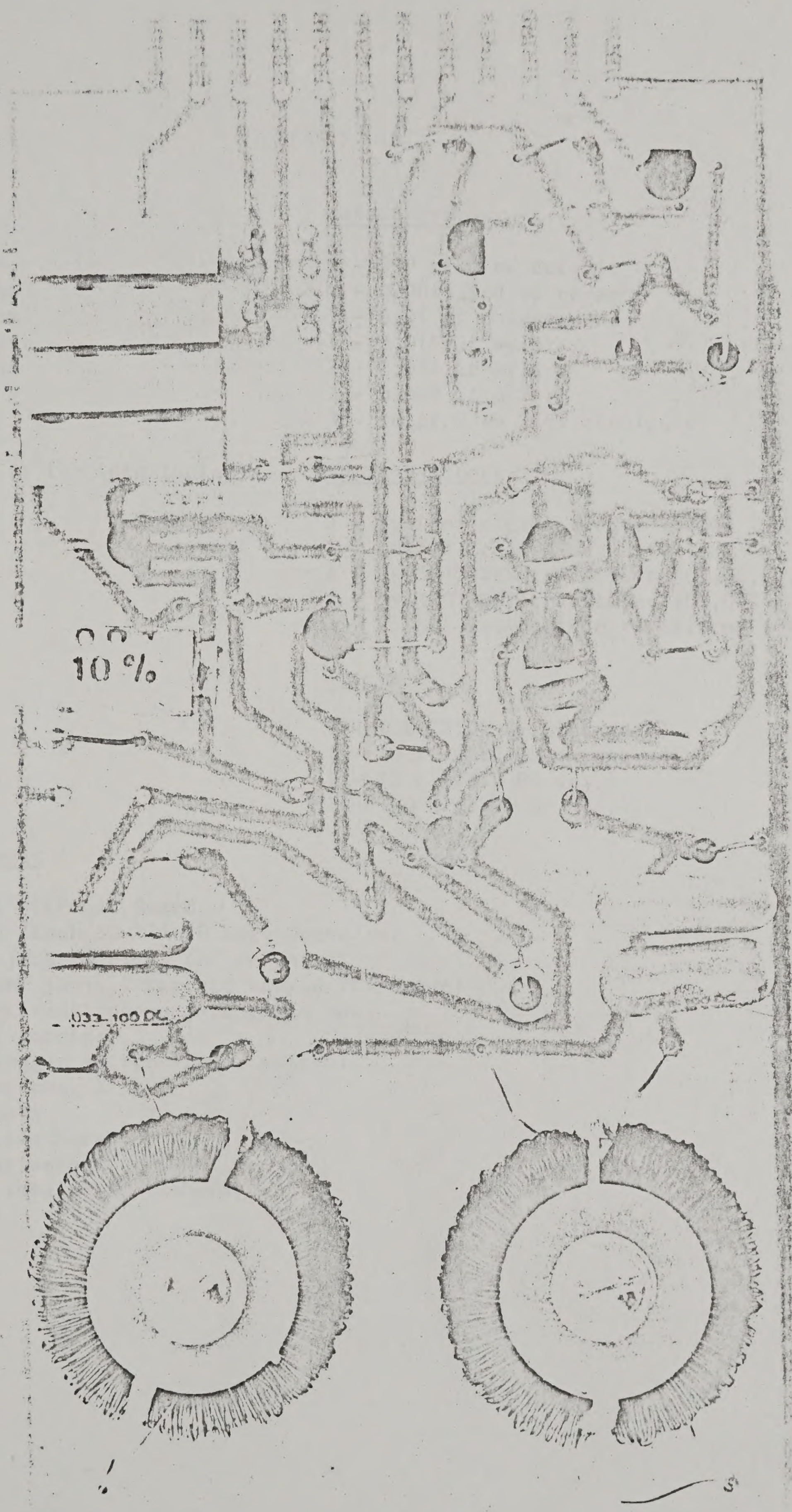
Now place the shift switch in the 170 Hz position and set the keying input for a space condition. Adjust R_6 for an output frequency of 2295 Hz. Change the shift switch to 850 Hz and adjust R_4 for an output frequency of 2975 Hz. Check the amount of CW ID shift by returning the keying signal to the mark condition and shorting the key jack - the frequency should shift to approximately 2225 Hz in either position of the shift switch. This frequency can be adjusted by changing the value of R_8, but this is normally not necessary. As discussed previously, resistor locations R_a, R_b, and R_c have been provided to allow further trimming of the total series resistance for each tone if necessary. Experience has shown that the ranges of the

potentiometers are sufficiently great to account for component tolerances and it should therefore be possible to adjust all of the tones directly without changing or adding resistors.

The low-pass filter requires no adjustment. Proper performance is indicated by comparing the output voltage for 2125 Hz with that of 2975 Hz. The two levels should be within 0.5 dB of each other if the filter is performing correctly. As mentioned earlier, resistor location R_x is provided to allow a small amount of space-tone pre-emphasis. The audio stages of some transmitters may tend to have slightly reduced output of 2975 Hz as compared with 2125 Hz. Insertion of a resistor at R_x forms a single-pole low-pass filter with C_{10} and can, in some cases, provide some compensation of the low-level space carrier output. It should be noted, however, that both tones will suffer some attenuation and it is impractical to try to compensate for more than a 2.0 dB difference in levels with this technique.

When the HAL AK-1 is constructed as a part of the HAL ST-6, the alignment procedure can be somewhat modified and portions of the ST-6 used in the test. After it is determined that supply voltages and currents are correct and that the oscillator is functioning correctly, connect the 100 mV output of the AK-1 to the audio input of the ST-6. Put the ST-6 AUTO-STAND-BY switch in STAND-BY position and the LIMITER switch in the ON(FM) position. Connect the frequency counter to pin 8 of the edge connector of the number 1 board for the shift under test (i.e., for the 170 Hz shift, connect the counter to 1-170(8) and for 850 Hz shift to 1-850(8)). This technique has the advantage that the input bandpass filter and limiter stages of the ST-6 serve as counter input stages, reducing noise, increasing signal strength, and improving accuracy of the measurement. With the controls set in this fashion and the printer jack of the ST-6 unconnected to anything (self-shorting), the AK-1 is in the mark condition and the 2125 Hz tone can be adjusted as before. To obtain the space condition, plug an unconnected plug into the ST-6 printer jack, opening the loop. Now adjust the space tones - note that it is necessary to move the counter connection point from one board no. 1 (pin 8) to the other when changing shifts.

An interesting variation of this technique is that the AK-1 can be used to check the center-frequency of the ST-6 discriminators by simply observing the frequencies at which peaks on the ST-6 tuning meter occur.


10 %
.033-100 DC

8. PARTS LIST

Resistors

1 - 27 ohm
1 - 120 ohm
2 - 220 ohm
1 - 470 ohm
1 - 750 ohm
3 - 1 K
1 - 1.2 K
2 - 2.2 K
2 - 4.7 K (1 for interfacing)
1 - 5.6 K
2 - 10 K
1 - 15 K
1 - 18 K
3 - 22 K
3 - 33 K
1 - 180 K
1 - 430 K

Capacitors

2 - 500 pf disc ceramic
4 - 0.001 µf disc ceramic
1 - 0.01 µf polystyrene
1 - 0.015 µf mylar
2 - 0.033 µf mylar
1 - 0.068 µf mylar
3 - 10 µf @ 16 V electrolytic

Semiconductors

2 - silicon signal diodes 1N4148
1 - 1N4738 Zener diode
4 - MPS3394 NPN transistor (Q1,Q5,Q6,Q7)
2 - MPS3703 PNP transistor (Q2,Q3)
1 - 2N4871 unijunction transistor (Q4)

Trim-pots

1 - 1 K (2125 Hz fine adj.)
1 - 10 K (2125 Hz corase adj.)
1 - 25 K (2975 Hz adj.)
1 - 200 K (2295 Hz adj.)

Miscellaneous

1 - 3" x 6" Circuit Board
1 - 12 pin Cinch 50-12A-20 Edge Connector
2 - phono jacks & plugs (AF outputs)
1 - ¼" phone jack, 1 circuit (keyed TTY input)
1 - ¼", 2-circuit phone jack (Hand Key)
2 - 88 mhy toroids
1 - DPDT toggle switch (shift switch)
2 - 6-32 screws, 1" L
2 - 6-32 nuts
2 - #6 lockwashers
2 - #6 flatwashers
2 - nylon insulating washers
1 - Manual